Q.630.7
Il 6sr
no.49
text
cop.5

UNIVERSITY OF ILLINOIS
[redacted]

WAYNE COUNTY SOILS

[redacted]49

UNIVERSITY OF
ILLINOIS LIBRARY
AT URBANA-CHAMPAIGN
AGRICULTURE

UNIVERSITY OF ILLINOIS

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 49

WAYNE COUNTY SOILS

By E. A. NORTON, R. S. SMITH, E. E. DeTURK
F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, JUNE, 1931

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

STATE ADVISORY COMMITTEE ON SOIL INVESTIGATIONS
1930-1931

F. I. Mann, Gilman
N. F. Goodwin, Palestine
G. F. Tullock, Rockford
W. E. Riegel, Tolono
F. S. Haines, Geneseo

RESEARCH AND TEACHING STAFF IN SOILS
1930-1931

Herbert W. Mumford, Director of the Experiment Station
W. L. Burlison, Head of Agronomy Department

Soil Physics and Mapping
R. S. Smith, Chief
D. C. Wimer, Assistant Chief
E. A. Norton, Assistant Chief
R. S. Stauffer, Associate
D. C. Maxwell, First Assistant
Eric Winters, Jr., Assistant
Herman Wascher, Assistant
G. D. Smith, Assistant
J. E. Gieseking, Assistant

Soil Fertility and Analysis
E. E. DeTurk, Chief
F. H. Crane, Associate
R. H. Bray, Associate
J. C. Anderson, First Assistant
L. K. Eby, Assistant
E. B. Earley, Assistant
K. B. Daniloff, Assistant
C. N. Darras, Assistant
L. E. Kehoe, Assistant
A. W. Klemme, Assistant

Soil Experiment Fields
F. C. Bauer, Chief[1]
H. J. Snider, Assistant Chief
A. L. Lang, Associate
C. J. Badger, Associate
L. B. Miller, Assistant
C. H. Farnham, Assistant
Allan Kirkwood, Assistant
P. E. Johnson, Assistant
K. A. Potter, Assistant

Soil Biology
O. H. Sears, Associate Chief
M. F. Hershberger, Assistant
L. E. Allison, Assistant

Soils Extension
F. C. Bauer, Professor[1]
C. M. Linsley, Assistant Professor

Soil Survey Publications
L. H. Smith, Chief
F. W. Gault, Scientific Assistant
Nellie Boucher Smith, Editorial Assistant

[1] Engaged in Soils Extension as well as in Soil Experiment Fields.

UNIVERSITY OF ILLINOIS
AGRICULTURE LIBRARY

INTRODUCTORY NOTE

IT IS A MATTER of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil management, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation.

LIBRARY
UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

CONTENTS

PAGE

GEOGRAPHICAL FEATURES OF WAYNE COUNTY 3
- Agricultural Production 3
- Climate 6
- Physiography and Drainage 7

FORMATION ON WAYNE COUNTY SOILS 9
- Sources of Soil Material 9
- Soil Development 10

THE SOIL MAP 12
- Basis of Soil Classification 12
- Naming the Soil Types 12

DESCRIPTION OF THE RESPECTIVE SOIL TYPES 14
- Deep Gray Silt Loam On Tight Clay 14
- Gray Silt Loam On Tight Clay 15
- Gray Silt Loam On Orange-Mottled Tight Clay 17
- Yellowish Gray Silt Loam On Orange-Mottled Tight Clay 17
- Deep Gray Silt Loam 18
- Light Gray Silt Loam On Tight Clay 18
- Yellow-Gray Silt Loam On Tight Clay 18
- Yellow-Gray Silt Loam On Compact Medium-Plastic Clay 19
- Eroded Gravelly Loam 20
- Mixed Loam 20
- Grayish Drab Silt Loam On Clay 20
- Yellow-Gray Silt Loam On Clay 21
- Gray Silt Loam On Clay 21
- Drab Clay Loam 22
- Drab Clay 22
- Mixed Fine Sandy Loam 22
- Deep Gray Silt Loam 23
- River Sand 23

CHEMICAL COMPOSITION OF WAYNE COUNTY SOILS 24
- Most Types Deficient in Organic Matter and Nitrogen 25
- Phosphorus and Sulfur Less Closely Associated With Organic Matter 26
- Potassium Content Comparatively Uniform 27
- Wide Variations in Calcium and Magnesium 27
- Local Tests for Soil Acidity Often Required 28
- Character of Chemical Combination Related to Availability 28
- Service of Chemical Investigations in Soil Improvement 29

FIELD EXPERIMENTS ON SOIL TYPES SIMILAR TO THOSE IN WAYNE COUNTY 30
- Fairfield Field 31
- Newton Field 38
- Ewing Field 40
- Sparta Field 42
- Raleigh Field 43

APPENDIX

PRINCIPLES OF SOIL MANAGEMENT 45
- Providing Adequate Drainage 46
- Protecting Soil From Erosion 47
- Applying Limestone to Correct Acidity 49
- Maintaining a Well-Planned Crop Rotation 50
- Supplying Right Kinds and Amounts of Organic Matter 53
- Mineral Plant-Food Requirements and Supply 54
  - Nitrogen Problem 56
  - Phosphorus Problem 58
  - Potassium Problem 60
  - Use of Mixed Commercial Fertilizers 60

WAYNE COUNTY SOILS

By E. A. NORTON, R. S. SMITH, E. E. DeTURK, F. C. BAUER AND L. H. SMITH[1]

GEOGRAPHICAL FEATURES OF WAYNE COUNTY

WAYNE COUNTY is located in southeastern Illinois. It is rectangular in shape, 30 miles east and west by 24 miles north and south. It is one of the largest counties in southern Illinois, comprizing over 700 square miles. The population in 1930 was 19,130, most of which was rural. Fairfield is the principal town and the county seat.

The earliest settlers came from Kentucky, but those who came later were from Ohio and Indiana. The population of the county grew rapidly after its founding in 1819 until the year 1870. After that date the rate of growth diminished and the maximum of population was reached about 1900. Since then there has been some decline (Fig. 1). Most of the decline has been in rural districts, from which many young people have migrated to towns and cities.

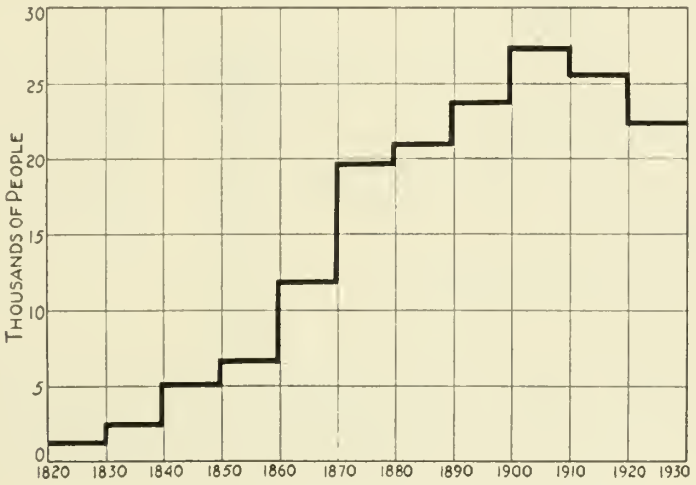


FIG. 1.—GROWTH IN POPULATION OF WAYNE COUNTY

Population reached its maximum in the first decade of the present century, since which time it has declined.

Markets are readily accessible, both auto truck and railroad transportation being well developed thruout the county. Concrete paved roads and secondary gravel roads make it possible for every farmer to be within a few miles of an all-weather road. Rural educational facilities and social life are well developed. Farm buildings and equipment indicate moderate prosperity in most of the communities in the county.

Agricultural Production

Early agriculture in Wayne county consisted of raising food for the people and enough grain and hay to winter the livestock. Some livestock and livestock

[1] E. A. NORTON, Assistant Chief in Soil Survey Mapping; R. S. SMITH, Chief in Soil Physics, in charge of identification and mapping of soil types; E. E. DeTURK, Chief in Soil Technology, in charge of soil analysis of the Soil Survey; F. C. BAUER, Chief in Soil Experiment Fields; L. H. SMITH, Chief, in Charge of Publications of the Soil Survey.

products were marketed by being driven or hauled overland to towns on the Wabash and Ohio rivers. Much of the land remained in grass to serve as pasture and no surplus grain was harvested in the early days because of the lack of a market. Following the completion of railroad transportation out of the county in the seventies, attention was given to raising grain for market. The number of farms and the crop acreage expanded rapidly.

The land area in farms in 1925 was 382,149 acres, about 84 percent of the total county area. There were 3,635 farms, and these had an average area of about 105 acres. Both the land area in farms and the number of farms in the county have shown a decided decrease since 1900. The average size of farms has increased slightly during that same period. The proportion of tenantry in Wayne county has remained about 26 percent since 1900.

The principal crops grown in Wayne county are those common in north-central United States. The following figures, taken from the United States Census of Agriculture for 1925, give the acreage, production, and yield per acre of the more important crops.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn (total acreage)	73,369	.....	....
Corn (harvested for grain)	69,117	1,592,708 bu.	23.0 bu.
Oats (threshed for grain)	6,927	149,788 bu.	21.6 bu.
Oats (cut and fed unthreshed)	1,449	.....	....
Wheat	3,580	33,604 bu.	9.3 bu.
Hay (total acreage)	98,843	60,226 tons	.6 ton
Hay (timothy alone)	6,478	.....	....
Hay (timothy and clover)	1,322	.....	....
Hay (clover, red, alsike and mammoth)	1,128	.....	....
Hay (other tame grasses, mostly redtop)	76,898	.....	....
Hay (annual legumes)	10,633	.....	....

The above figures are for but a single year, that of 1924. Yields, however, fluctuate from year to year, depending largely upon the season, and therefore the average yield over a period of years is more representative. For the eighteen-

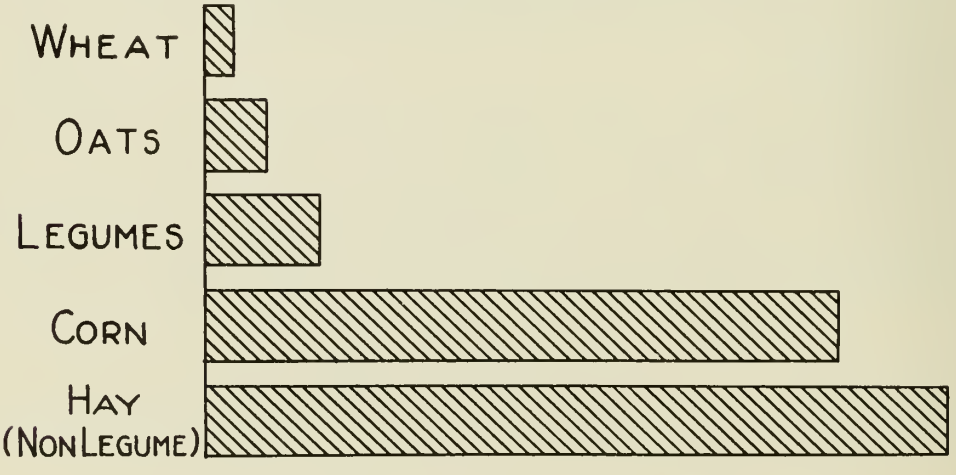


FIG. 2.—RELATIVE ACREAGE OF PRINCIPAL CROPS IN WAYNE COUNTY

The diagram brings out the small proportion of land devoted to legumes. A well-balanced system for soil improvement demands a much larger acreage of legume crops. (Data from U. S. Census of Agriculture, 1925)

year period 1911-1929 the U. S. Department of Agriculture gives the acre-yield of the four most important crops in Wayne county as: corn, 24.1 bushels; wheat, 11.3 bushels; oats, 20.0 bushels; tame hay, .94 ton per acre. These yields are considerably below the all-state average.

The predominance of acreage given over to corn and nonlegume hays, as shown in Fig. 2, indicates that more diversification might well be practiced. Census figures indicate that the percentage of crop acres in legumes was considerably less in 1928 than in 1925; in fact there was less than 5 percent of the total crop area of Wayne county in legumes in 1928. At least 20 percent of

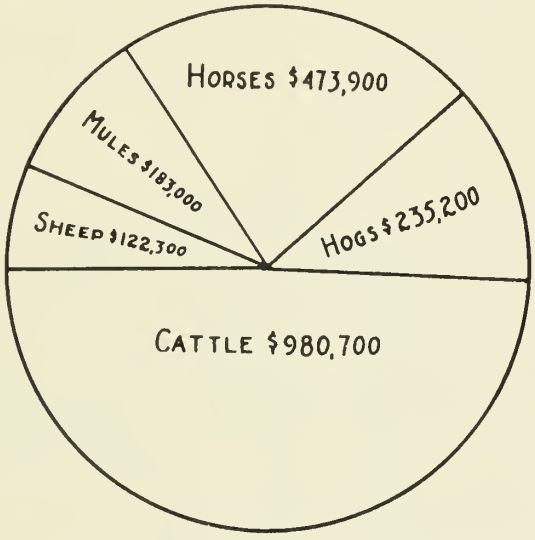


FIG. 3.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN WAYNE COUNTY
(Data from U. S. Census of Agriculture, 1925)

the cultivated land should be in legumes, and a good crop rotation should include a legume every three or four years.

Fruit and vegetable crops are not of great commercial importance in Wayne county. Orchards are being developed near Fairfield and in the western and northwestern parts of the county. Some of these have proved profitable. Peaches and apples are the principal orchard fruits grown. The fruit is marketed largely by truck. Practically all vegetables raised are consumed locally. Undoubtedly special vegetable and fruit crops could be grown profitably if placed on a commercial basis.

Regarding the growth of the livestock industry in Wayne county it may be said that the number of horses and mules and hogs increased steadily up to about the year 1900, following which a decline set in. By 1928 the number of each had declined to less than half the maximum number. In recent years a considerable interest in dairying and poultry raising has developed. The character of the livestock interests in the county in 1925 is shown by the Census figures given on page 6.

Animals and animal products	*Number*	*Value*
Horses	9,812	$524,710
Mules	3,236	215,816
Cattle (total)	22,560	820,877
Dairy cattle	7,583	.....
Dairy products	....	312,996
Sheep	9,736	96,137
Hogs	16,466	172,888
Chickens	562,868	517,839
Chickens and eggs produced	....	1,297,349
Wool	....	19,699

Estimates made by the U. S. Department of Agriculture and the Illinois State Department of Agriculture, as of January 1, 1929, indicate that the number and value of horses, mules, and all cattle have decreased since 1925. The number and value of dairy cattle, hogs, and sheep have made some increase during that same period. Fig. 3 shows the relative value of the important classes of farm animals in Wayne county on January 1, 1929.

Climate

The climate of Wayne county is typical of that prevailing in north-central United States. It is characterized by a wide range between the extremes of winter and summer and by an abundant rainfall. The average yearly range of temperature is about 100 degrees. During the years 1909 to 1930 the highest temperature recorded at the weather station located at Fairfield was 108° in 1914 and 1918; the lowest was 18° below zero in 1912 and 1918. The average date of the last killing frost in spring is April 16; the earliest in autumn is October 20. The latest recorded killing frost in spring occurred May 2, 1924, and the earliest killing frost in autumn was September 19, 1901.

The average length of growing season is 187 days, which is ample time to mature all the common crops grown in the region. Occasionally early autumn frosts result in the production of soft corn, especially under conditions of late planting. Winter wheat and legume crops are often injured, particularly on flat ground, owing to the freezing and thawing following sudden temperature changes in winter and early spring. Hot early summer weather often cuts the yield of spring-sown small grain. Prolonged periods of hot, dry weather frequently reduce the yields of corn and other crops that mature in autumn.

The prevailing wind direction in spring and summer is south. Spring winds are usually brisk from the southwest, those of summer relatively calm except before thunder showers. A series of strong northwesterly gales, which bring cold waves followed by periods of calm, characterize the winter winds. Wayne county lies within the region subject to tornadoes but none resulting in serious destruction are known to have visited the area.

The average annual rainfall, as recorded at Fairfield for the last thirteen years, is 41.01 inches. The average rainfall during the growing season thru this same period has been 24.10 inches. The annual rainfall has varied from a minimum of about 30 inches to a maximum of about 60 inches. Some of the yearly precipitation falls as snow in the winter months. A yearly average of 12 inches of snow has been recorded. Sleet storms are not uncommon, and they

have caused considerable damage to wheat, clover, and grasses. Occasionally hail storms occur in late spring and summer but their damage is usually local.

The average amount of rain during the growing season in Wayne county would indicate that crops should not suffer from either a lack or an excess of moisture in the soil. Average rainfall, however, is not the only factor to be considered in wet or drouthy periods. The rate at which rain falls, lapse of time between precipitation periods, evaporation, crop demand, and character of the soil with particular reference to its water absorptive power and moisture movement are other important factors determining the moisture conditions for plant growth. No records are available concerning the rate at which rain falls, but much of the water falling during prolonged spring rains and in hard, dashing thunder showers of summer is likely to be more destructive than beneficial. The run-off during these rains makes erosion a problem on rolling land, and on flat land the accumulation of water in ponds drowns vegetation.

The rainfall during the growing season is not very favorably distributed despite the rather liberal average of 24 inches. An analysis of the records at Fairfield for the years 1917 to 1930 reveals that an average of nearly five 11-day, or longer, "rainless periods" occurred every season, and on the average two of these dry periods extended to 20 days or longer. In this study a rain of .5 inch or more was arbitrarily chosen as breaking a rainless period. Most of these rainless periods occurred during July and August when both the evaporation rate and the temperature are high and when growing crops demand the most moisture. There were several 40-day rainless periods and one of 50 days duration recorded during this thirteen-year period. All of these long periods would reduce moisture in the soil to a very low amount and seriously affect plant growth. On the other hand the records indicate frequent wet periods, when an excess of rainfall makes the soil wet and unfavorable for cultivation and increases run-off and erosion.

The character of the soils in Wayne county is such as to intensify unfavorable conditions arising from weather that is either too wet or too dry. These soils are generally low in organic matter and consequently have a low water-holding capacity. During rainy periods they become saturated quickly with water which they do not readily retain as a supply for drouths. The rolling upland soils have a loose, open subsoil which allows water to pass thru readily but which does not retain enough to supply the surface by capillarity during dry periods. The upland soils on flat and intermediate topography have a very compact, plastic, and slowly pervious subsoil which impedes water movement. The surface soil soon becomes saturated and water accumulates in ponds during rainy periods whereas, after the surface soil dries, capillary movement of water from below is shut off by the impervious subsoil. Thus both wet and drouthy periods are of rather frequent occurrence in Wayne county as a result of a combination of climatic and soil features.

Physiography and Drainage

The general elevation of Wayne county is between 375 and 500 feet above sea level. The altitudes of a few places in the county are as follows: Barnhill,

385 feet above sea level; Cisne, 460; Fairfield, 452; Merriam, 406; Keenes, 444; Wayne City, 429. The general upland level lies about 450 feet, being higher in the north part of the county and sloping gently to the south. The northern, central, and western parts of the county are rather smooth, the upland being flat and sloping gradually into the bottom land. In the northwestern part of the county small streams have cut into the flat upland, forming steep gullies. The upland in the eastern part of the county is rolling, particularly east of Barnhill, and altho there is not much gullying, slope washing has made much of the land unfit for cultivation.

Wayne county is drained by Little Wabash river and its principal tributary, Skillet Fork creek. These streams flow southeast and are a part of the Wabash-Ohio river system. Fig. 4 shows the stream courses and other physiographic features of the county. Even tho drainage channels penetrate almost every section in the county, the land is not well drained. There are two reasons for this. In the first place much of the upland does not have a sufficient slope for water to drain away naturally, and then, with the impervious subsoil underlying the flat land, water is not removed thru the subsoil. The rolling land in the eastern part of the county is well drained, but because of its slope it is subject to serious erosion. The bottom lands, particularly of Skillet Fork creek, are frequently flooded and remain wet until summer. A few dredges and levees in the large

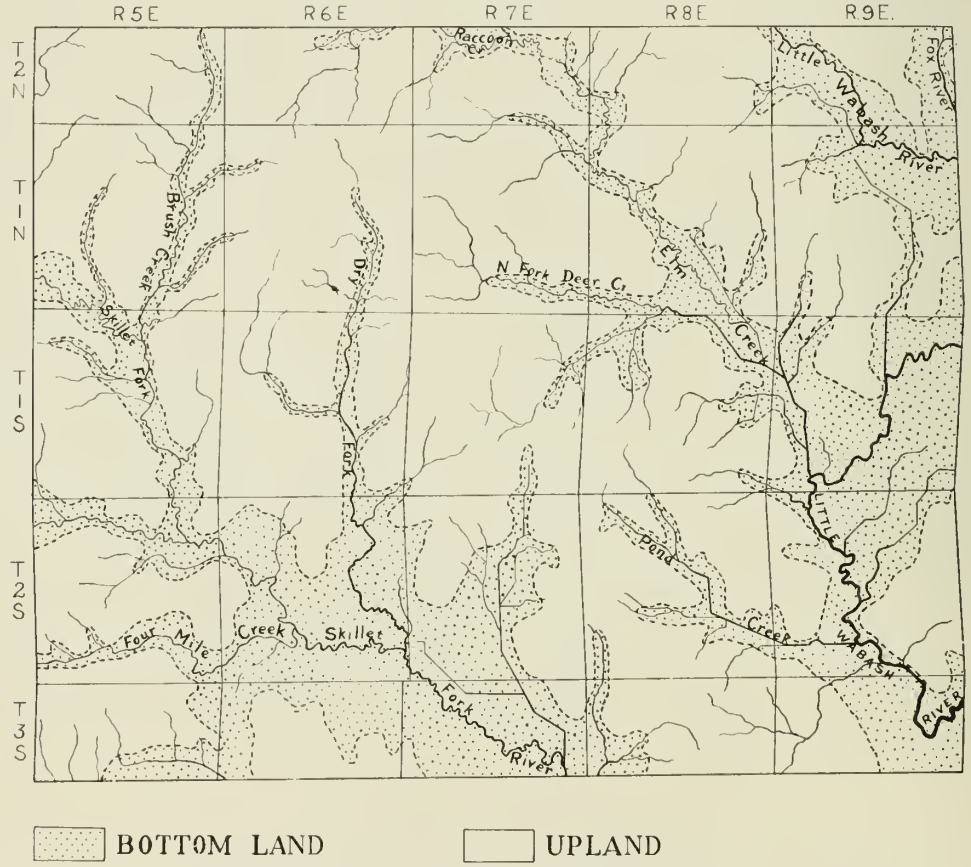


FIG. 4.—DRAINAGE MAP OF WAYNE COUNTY SHOWING STREAM COURSES, UPLAND, AND BOTTOM LAND

bottom land of Little Wabash river have made certain areas available for cultivation. The bottom land can be artificially drained but in view of the present economic situation each project should be carefully considered before any attempt is made to correct drainage.

FORMATION OF WAYNE COUNTY SOILS

Sources of Soil Material

The bed rock which serves as a foundation for the material above it was formed in this region during a remote period of geological time. It was derived from rock sediment swept into a shallow sea. The sediment accumulated until finally it was consolidated into rock by pressure from above. At the close of this geological period the arm of the sea which extended over this region withdrew and the rock surface emerged as dry land. Exposure immediately subjected it to weathering and destruction, the rock being broken apart and distintegrated into fine particles. Erosion set in, gradually removing the loose material. After a prolonged period the flat surface became rough and broken, and hills and valleys were formed. A change in regional climate closed the cycle of erosion and ushered in another geological period, known as the Glacial Epoch. The material now forming the mineral portion of the present soils was deposited during this Glacial period.

During this Glacial period snow and ice accumulated in regions to the north in such an amount that the mass pushed outward from these centers. The ice advanced chiefly southward, aided by further accumulations of snow and ice at its margin, until it reached a region where the climate was warm enough to melt the ice as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of materials, including clay, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried hundreds of miles and rubbed against surface rocks and against each other until largely ground into powder. The great bulk of material carried, however, was derived from the old bed-rock surface and deposited perhaps within fifty miles or less of its origin. When the glacier reached the limit of its advance, the rock debris carried by it accumulated along its front in a broad undulating ridge or moraine. With rapid melting the glacier receded, and the material was deposited somewhat irregularly over the land surface. The advance and retreat of an ice sheet were not regular, uninterrupted movements; oscillations took place frequently and the action was complex in character. Each advance and retreat leveled off ridges and hills and filled in valleys. The mixture of materials deposited by the glacier is known as boulder clay, or glacial drift.

There were at least four great periods during which ice sheets moved down from the north. Some periods included two or more distinct movements, each of which covered a part of North America, altho the same parts were not necessarily covered during each advance. The movements of these individual ice sheets were separated by long periods of time during which the climate was similar to that now existing and the country was clothed with vegetation. At least one of these glaciers, the Illinoian, covered Wayne county. Probably none of the earlier

glacial advances reached the area, but if they did all trace of their deposit was destroyed by the Illinoian ice. The deposits left by the Illinoian ice sheet formed a heterogeneous gravelly, clayey mass varying in thickness from ten to more than a hundred feet. The formerly rough, broken, and eroded surface was leveled off to a relatively flat plain. Only a few of the higher rock surfaces resisted the attack of the glacier. These can now be identified as the higher rolling areas, most of which are in the western and southwestern parts of the county.

Associated with the withdrawal of an ice sheet and exposure of the deposited material to the weathering forces was the accumulation, on top of the drift, of a silty, wind-blown material known as loess. The loess was derived largely from the sediment carried by the immense volumes of water which flowed from the melting ice sheet. This sediment-laden water filled the drainage channels and overflowed adjacent lowlands during flood stages. Following each flood-stage, the water would recede and the sediment which had been deposited would dry, be picked up by the wind, and blown over and redeposited on the upland as dust. Most of the loess was derived from the major stream valleys, those of the Wabash and Mississippi rivers, and as Wayne county is some distance from a major valley it did not receive a very thick blanket of this material.

The thickness of the loess over the county, where it has not been eroded away, varies from one to three feet, the average being about two feet. Not all this loess came at the same time, however, as each glacial advance and retreat was accompanied by a loess accumulation. Most of the loess covering Wayne county was deposited during two periods: the earlier, known as the Sangamon interglacial period, which followed the Illinoian ice; and the later, known as the Peorian interglacial period, which followed one of the later ice advances. This later ice advance did not reach Wayne county but the major river valleys were filled to overflowing with water from its melting, and some of the sediment deposited in them was blown over the region accumulating as a shallow deposit. Enough time elapsed between the deposition of the drift and the oncoming of the loess so that a soil was formed from the drift. Altho this drift-derived soil was buried by the deposition of loess, it exerted an influence on the characteristics of the present surface soil, as will be brought out later.

Soil Development

The soil material, that is to say the glacial till and the silty loess, when first deposited in Wayne county, had only a few features of the present-day soils. Its composition was rather uniform from top to bottom and over the area of the county. It was of a generally open, porous nature, gray to pale yellowish gray in color, high in carbonates, and well supplied with the mineral elements of plant food. Altho this material was sweet and potentially productive, it was raw and incapable of growing crops. It had yet to be made into soil by the operation of weathering forces.

As time went on, the weathering forces began to leave their imprint in the material. Soil is not formed all at once, but attains its characteristics gradually. Soil has youth, maturity, and old age, a growth and life cycle similar to that of

living beings. The upland soils in Wayne county have reached maturity and are entering old age. Their characteristics are clearly and definitely expressed. Soils receiving deposition as in bottom land, or those subject to erosion as on sloping land, are youthful soils because the material has been either recently deposited or recently uncovered.

Thus the soil material was being continuously subjected to climatic agencies such as freezing and thawing, wetting and drying; which served to break the larger particles into smaller ones. Oxidation and hydration are among the first of the chemical processes to act in breaking down the complex soil minerals. Leaching of the carbonates follows as a further process of weathering. Ground water from rains soaking into the soil material dissolves the carbonates, and in solution they pass out with the drainage water. Limestone is one of the readily soluble carbonate compounds. All the soil material in Wayne county originally contained an abundance of lime and was sweet, or alkaline, in reaction. Gradual leaching of lime from the soils has made them sour, or acid, in reaction. Most crop plants demand a nearly neutral or slightly alkaline reaction for proper growth.

Some of the materials released by decomposition of the minerals went into solution and passed out with the drainage water; the insoluble portions accumulated in place. The release of chemical elements furnished an abundance of plant food. The breaking down of the larger particles into smaller ones made many particles so small that they were easily moved in solution or suspension in the soil water. Under conditions of poor subsurface drainage these fine particles accumulated in the subsoil, filling in the spaces between the larger particles and thus starting the formation of a layer slowly pervious to water. This clay-pan layer gradually increased in thickness and became more and more impervious thru continued accumulations in place.

Early in the history of the weathering of the soil material plant seeds were distributed and vegetation spread over the land. The simpler forms of vegetation came first, followed by the higher plants. Rapid chemical decomposition made an abundance of plant food available, and the soil supported a luxuriant plant growth. The conditions were more favorable at first for the development of a grass vegetation; but as streams were extended into the region and drainage improved, forest vegetation began to encroach. The grass vegetation, with its enormous quantity of surface roots together with a high lime and moisture content in the soil, resulted in the accumulation of organic matter and the development of dark color in the surface soil. As weathering continued, the soil became acid and somewhat impoverished, vegetative growth became less vigorous, and organic-matter destruction overtook accumulation, reducing the once dark brown or black surface soil to a gray. In timbered areas the surface soil is still lighter in color because the trees used up much of the organic matter for their growth and failed to replace it. The continued oxidation and decay of organic matter in the soil produced organic acids which furthered the reduction of the mineral matter. This action was probably responsible for the development of the light gray or white, ashy subsurface layer which occurs in all upland soils formed on poorly drained land of flat topography.

The gradual development of soil from soil material is very complex in nature, and the above described processes are only a few of the outstanding changes which take place. One of the most pronounced and universal effects of the weathering of soil material is the production of layers, or zones, in the soil, each zone having more or less definite characteristics. From a practical standpoint, these various zones can be grouped into surface, subsurface, and subsoil. The surface soil is the upper 3 to 10 inches—that part which is cultivated and in which most plant roots are found. The subsurface lies immediately below the surface, and is usually lighter in color and texture than the surface. The subsoil begins at depths varying from 12 to 24 inches and extends down several feet. It has two divisions. The upper subsoil is the most compact and plastic layer in the soil. The lower subsoil is usually more friable than the upper and is yellowish in color. Each of these major soil layers may have two or more sub-zones.

Differences in the arrangement, thickness, and nature of the features of the respective zones constitute the basis upon which soil types are separated.

THE SOIL MAP

Basis of Soil Classification

In the soil survey the "type" is the unit of classification. Each soil type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, zones, or "horizons" which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Topography and kind and character of vegetation are easily observable features of the landscape which are very useful indicators of soil character. A knowledge of the geological origin and formation of the soil material of the region being mapped often makes possible an understanding of the soil conditions which occur.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Naming the Soil Types

In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a somewhat definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of more than one stratum, and it is impossible to describe each stratum in the type name. The color and texture of the surface soil are usually included in the type name, and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

LEGEND

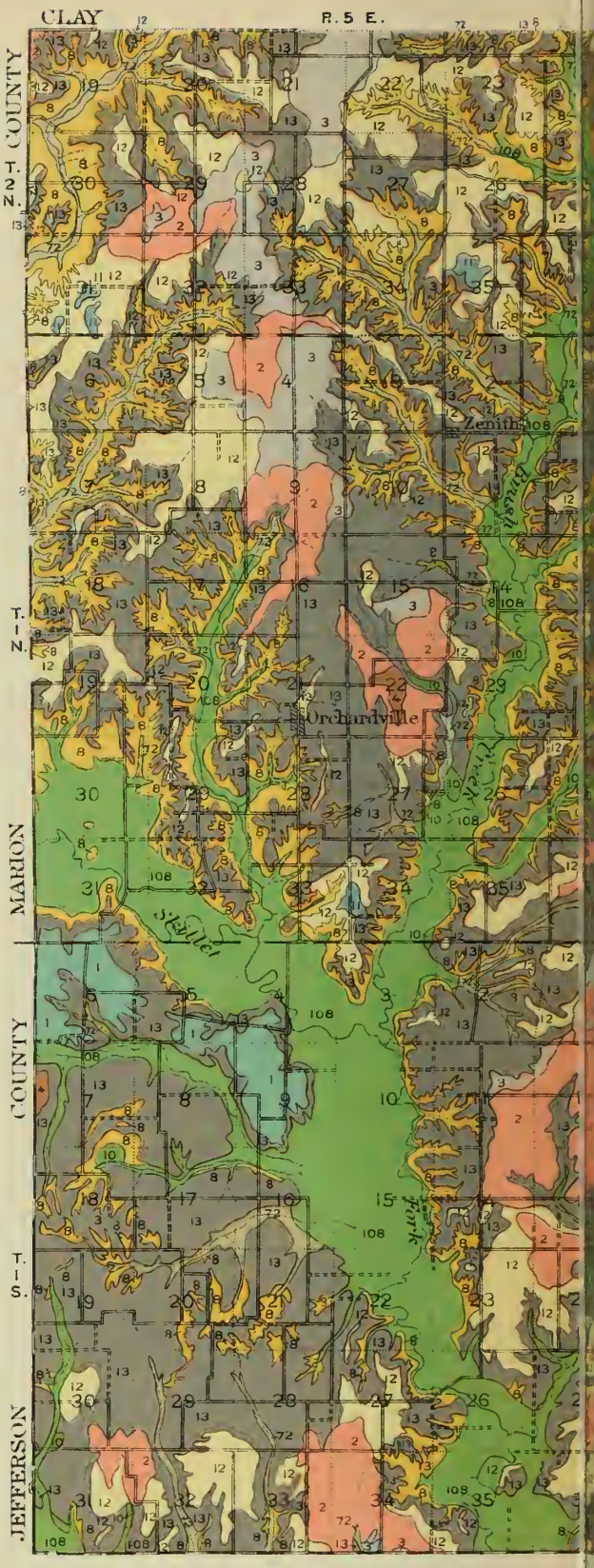
1	Deep Gray Silt Loam On Tight Clay
2	Gray Silt Loam On Tight Clay
3	Gray Silt Loam On Orange-Mottled Tight Clay
4	Yellowish-Gray Silt Loam On Orange-Mottled Tight Clay
10	Deep Gray Silt Loam
11	Light Gray Silt Loam On Tight Clay
12	Yellow-Gray Silt Loam On Tight Clay
13	Yellow-Gray Silt Loam On Compact Medium Plastic Clay
8	Eroded Gravelly Loam
72	Mixed Loam
48	Grayish Drab Silt Loam On Clay
26	Yellow-Gray Silt Loam On Clay
84	Gray Silt Loam On Clay
70	Drab Clay Loam
71	Drab Clay
75	Mixed Fine Sandy Loam
108	Deep Gray Silt Loam (Overflow)
92	River Sand

CONVENTIONAL SIGNS

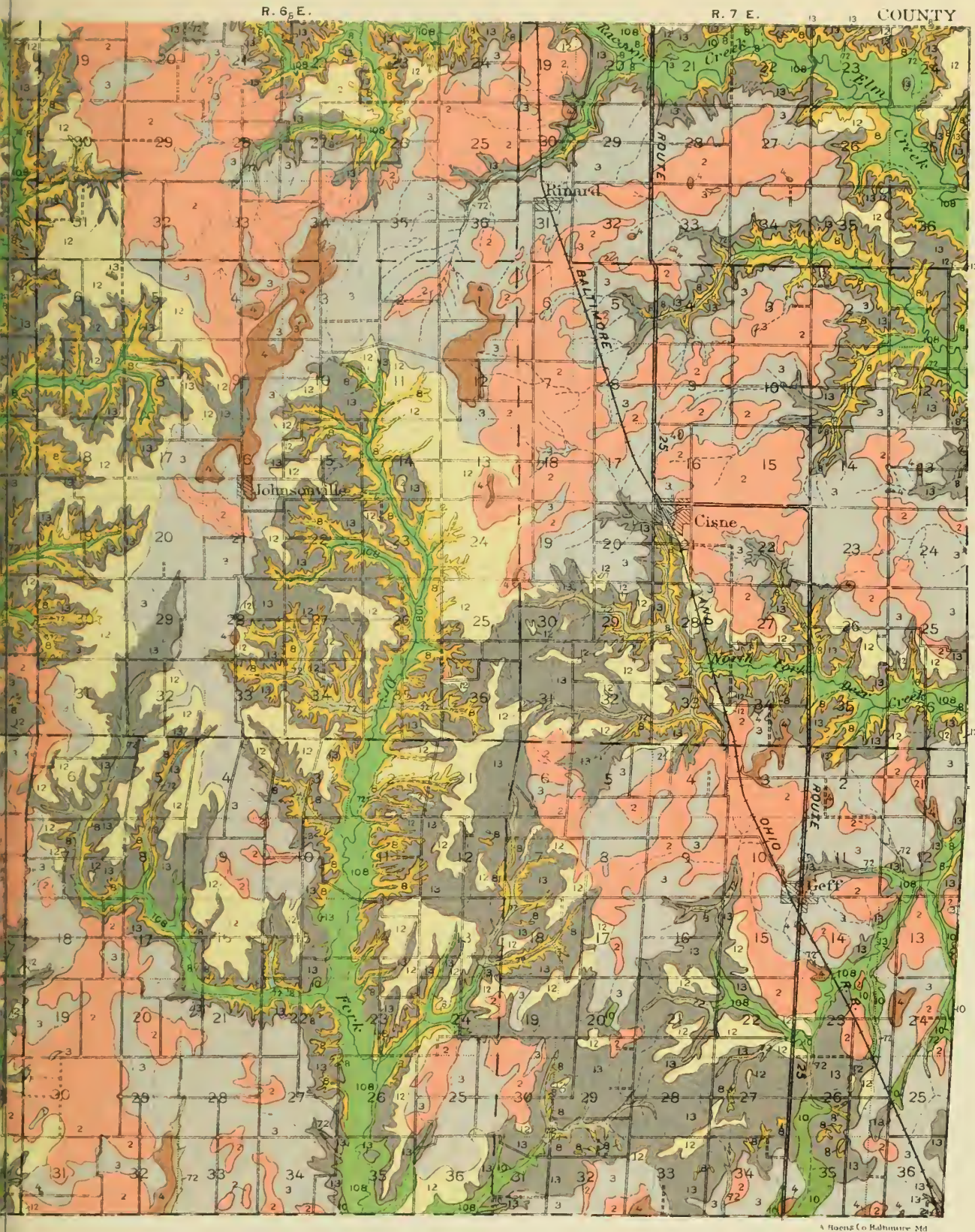
- Swamps
- Small areas sandstone outcrop
- Railroads
- Public roads
- Private roads
- Township lines
- County lines
- Paved roads
- Levee

Scale

0 ¼ ½ 1 2 Miles



S
UNIVERSIT



IL SURVEY MAP OF WAYNE COUNTY

T OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

FIG. 5.—STUDYING THE SOIL PROFILE
Deep natural exposures are made use of in studying the soil profile.

To assist in designating soil types, a number is assigned to each type. These numbers are not only a convenience in referring to the respective types but they are especially useful in designating very small areas on the map and as a check in reading the map colors.

Table 1 gives the list of the soil types as mapped in Wayne county, the area of each in square miles as well as in acres, and also the percentage that each type constitutes of the total area of the county.

TABLE 1.—SOIL TYPES OF WAYNE COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
1	Deep Gray Silt Loam On Tight Clay	11.78	7 539	1.68
2	Gray Silt Loam On Tight Clay	51.30	32 382	7.24
3	Gray Silt Loam On Orange-Mottled Tight Clay	111.71	71 494	15.77
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay	9.60	6 144	1.35
10	Deep Gray Silt Loam	21.82	13 965	3.08
11	Light Gray Silt Loam On Tight Clay	.17	109	.02
12	Yellow-Gray Silt Loam On Tight Clay	46.66	29 862	6.59
13	Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	189.29	121 146	26.72
8	Eroded Gravelly Loam	55.50	35 520	7.83
72	Mixed Loam	12.58	8 051	1.78
48	Grayish Drab Silt Loam On Clay	8.42	5 389	1.19
26	Yellow-Gray Silt Loam On Clay	7.69	4 921	1.08
84	Gray Silt Loam On Clay	5.31	3 398	.75
70	Drab Clay Loam	5.87	3 757	.83
71	Drab Clay	.52	333	.07
75	Mixed Fine Sandy Loam	.24	154	.03
108	Deep Gray Silt Loam (overflow)	169.86	108 710	23.97
92	River Sand	.17	109	.02
	Total	708.49	453 433	100.00

The accompanying colored map, shown in four sections, gives the location and boundary of each soil type and indicates the position of streams, roads, railroads, and town sites.

DESCRIPTION OF THE RESPECTIVE SOIL TYPES

Following is a brief description of the outstanding characteristics of the individual soil types as mapped in Wayne county. Along with the descriptions of the soils are given general recommendations on the care and management of each. It is impossible to outline a practical soil improvement and management program for a particular field or farm without knowing what soil types occur, what cropping and management practices have been followed in the past, and what type of farming it is desired to follow in the future. It is the purpose of this report to furnish the necessary information as to soil types and to bring out the main factors which should be considered in developing a soil management program. The soil type should serve as a basis in working out a soil improvement program. For example, the underdrainage in a soil developed on a flat surface is so different from that of a soil developed on a rolling slope that it entirely alters the management program. The first consideration in the improvement of the former is to remove the excess water, while in the latter it is to retard the rate of surface run-off and thus decrease erosion.

In the management and improvement of soils in Wayne county, the following points should be considered: drainage, erosion, supply of organic matter, soil reaction, and supply of the mineral elements of plant food. For a discussion of the underlying principles connected with these matters the reader is referred to the Appendix to this Report.

Deep Gray Silt Loam On Tight Clay (1)

Deep Gray Silt Loam On Tight Clay is found on bench land near streams, on second bottom lands, and in depressions in the upland at the base of long slopes or at the heads of drainage. The soil material which makes up this type was deposited as sediment from the run-off of adjoining higher land. Most of the area of the type still receives some of the silty wash brought down by sheet erosion. It is seldom covered by flood water except for a short period following heavy rains. The type occupies 11.78 square miles, or 1.68 percent of the total area of the county. It lies on nearly flat land which has a very gentle slope toward the bottom land, but not enough to remove excess surface water. Natural surface drainage and underdrainage are poor. The type was originally covered with a growth of grass, brush, and a few scattering swamp oak trees.

The surface soil of this type varies from 6 to 10 inches in depth, depending upon the rate of recent deposition. It is dark gray in color and is a friable, silt loam containing numerous small, hard, rounded, black iron pellets. The subsurface is lighter in color but of about the same texture as the surface. Its lower part is gray and ashy. The subsoil begins at 22 to 28 inches and varies from a thin, moderately compact and plastic clay loam to a thick, pale yellowish gray, very compact and plastic clay.

LEGEND

1	Deep Gray Silt Loam On Tight Clay
2	Gray Silt Loam On Tight Clay
3	Gray Silt Loam On Orange-Mottled Tight Clay
4	Yellowish-Gray Silt Loam On Orange-Mottled Tight Clay
10	Deep Gray Silt Loam
11	Light Gray Silt Loam On Tight Clay
12	Yellow-Gray Silt Loam On Tight Clay
13	Yellow-Gray Silt Loam On Compact Medium Plastic Clay
8	Eroded Gravelly Loam
72	Mixed Loam
48	Grayish Drab Silt Loam On Clay
26	Yellow-Gray Silt Loam On Clay
84	Gray Silt Loam On Clay
70	Drab Clay Loam
71	Drab Clay
75	Mixed Fine Sandy Loam
108	Deep Gray Silt Loam (Overflow)
92	River Sand

CONVENTIONAL SIGNS

- Swamps
- Small areas sandstone outcrop
- Railroads
- Public roads
- Private roads
- Township lines
- County lines
- Paved roads
- Levee

Scale
0 ¼ ½ 1 2 Miles

SOIL
UNIVERSITY

L SURVEY MAP OF WAYNE COUNTY

OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

Some sand and gravel are scattered thruout the soil. Slick spots, or scalds, are common on this type. The reader is referred to a discussion of these spots under the next described type, Gray Silt Loam On Tight Clay.

Management.—Drainage must first be provided in order to keep the run-off from adjoining higher land from spreading over the type, and to remove the excess surface water from rains. An open ditch at the base of the sloping upland above this type, combined with shallow ditches and short strings of tile thruout the area, should adequately drain this soil. The tile must be placed above the subsoil to be effective. The organic-matter content must be increased as a second step in improvement. Animal manure should be applied or legumes, preferably sweet clover, grown and plowed under. The soil is acid and should be tested and limestone applied according to need. A clover crop should be grown on the land every third or fourth year. Following the addition of organic matter, the land should be tested for phosphorus and a phosphate fertilizer applied if needed. If a liberal application of animal manure is not available, a trial application of a potassium fertilizer should be made. This type, when properly managed, should return fair crop yields. It will not grow alfalfa successfully, but corn, soybeans, cowpeas, grasses for seed or hay, should give moderate yields.

Gray Silt Loam On Tight Clay (2)

Gray Silt Loam On Tight Clay is found on the poorly drained, very gently sloping prairie upland. It comprizes over 50 square miles, or about 7 percent of the total area of the county. This soil is cold and wet in spring and drouthy in summer. It is characterized by an almost impervious subsoil. It is difficult to drain because of its flatness and the lack of an outlet for the water as well as the impossibility of underdrainage.

The surface soil is 6 to 8 inches thick and is a friable, dark gray silt loam. The subsurface is lighter in color and of about the same texture as the surface. The lower subsurface is an ashy, white silt loam. Both the surface and subsurface contain numerous small, hard, rounded, iron pellets. The subsoil begins at 18 to 22 inches and is a thick, pale yellowish gray, very compact and plastic clay. A few pale red or orange spots occur in its upper part. Some sand and gravel is found below 30 inches. The subsoil is slowly pervious to water to depths of 60 to 70 inches.

Slick spots, commonly known as scalds or alkali areas, frequently occur on this type. These spots can be recognized by their lighter colored surface soil, the pale yellowish or greenish gray color of their subsoil, and the stunted vegetative growth on them. Slick spots occur in conjunction with all types developed on poorly drained, flat to gently undulating land in Wayne county. They range in size from a few square feet to many acres. The formation of these spots is due to the interruption of the leaching of the chemical base material from the surface loess deposit, caused by the presence of a slowly pervious layer in the old drift soil beneath. The accumulation of the bases in the soil has produced high alkaninity and very poor physical condition. When dry, the slick spot subsoil becomes very hard, throws the plow out of the ground, and resists water penetration. When the subsoil is thoroly soaked, it readily absorbs still more water

FIG. 6.—COLUMNAR STRUCTURE IN SUBSOIL OF SLICK SPOT
This distinctly columnar formation occurs just beneath the surface horizons in Slick Spot areas.

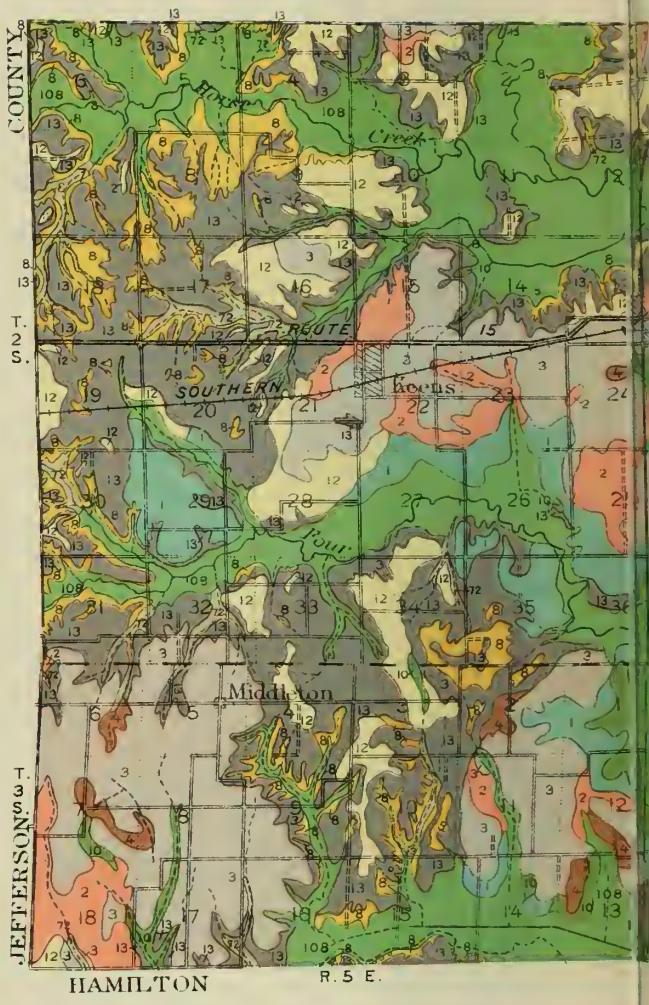
and seems to offer little resistance to pressure. Many bad mud holes in the roads develop on slick spots. Vegetation on these areas is stunted or entirely lacking.

Management.—Gray Silt Loam On Tight Clay is naturally very poorly drained, and adequate artificial drainage is practically impossible to secure. Because of this, as well as because of the presence of so many unproductive slick spots, it is questionable just how far to proceed with treatments aimed to increase production. Under ordinary conditions tile will not draw; open surface ditches placed 2 to 3 rods apart offer the only practical means of drainage, tho unless there is sufficient slope and a good outlet, even open ditches are not effective. The soil is low in organic matter and, except in the slick spots, is strongly acid. Animal or green manures must be plowed under in considerable quantity to increase the organic-matter content. Sweet clover is the best green-manure crop to use but it requires the application of considerable limestone. A trial application of a potassium fertilizer is suggested following the additions of organic matter. The results from the Station's experiment fields located on this soil type indicate that only a moderate return can be expected under the most favorable conditions. Alfalfa usually fails on this soil and corn is a rather uncertain crop. Without soil treatment, the raising of redtop for seed has been the most profitable practice on this type of land in recent years.

For the improvement of slick spots, thoro underdrainage must be provided. Where drainage cannot be provided, no attempt should be made to treat them. Where drainage can be effected, enough limestone should be applied to sweeten the surface soil and sweet clover should be seeded. The sweet clover may be allowed to reseed itself and remain on the land a number of years. Practical experience has shown that animal manure gives much greater return on other land than it does on slick spots. Crop yields on slick spots are never large; in fact they amount to practically nothing except in seasons when moisture conditions are ideal. Field experiments on this type are described in connection with the Newton field, page 38.

LEGEND

- 1 Deep Gray Silt Loam On Tight Clay
- 2 Gray Silt Loam On Tight Clay
- 3 Gray Silt Loam On Orange-Mottled Tight Clay
- 4 Yellowish-Gray Silt Loam On Orange-Mottled Tight Clay
- 10 Deep Gray Silt Loam
- 11 Light Gray Silt Loam On Tight Clay
- 12 Yellow-Gray Silt Loam On Tight Clay
- 13 Yellow-Gray Silt Loam On Compact Medium Plastic Clay
- 8 Eroded Gravelly Loam
- 72 Mixed Loam
- 48 Grayish Drab Silt Loam On Clay
- 26 Yellow-Gray Silt Loam On Clay
- 84 Gray Silt Loam On Clay
- 70 Drab Clay Loam
- 71 Drab Clay
- 75 Mixed Fine Sandy Loam
- 108 Deep Gray Silt Loam (Overflow)
- 92 River Sand

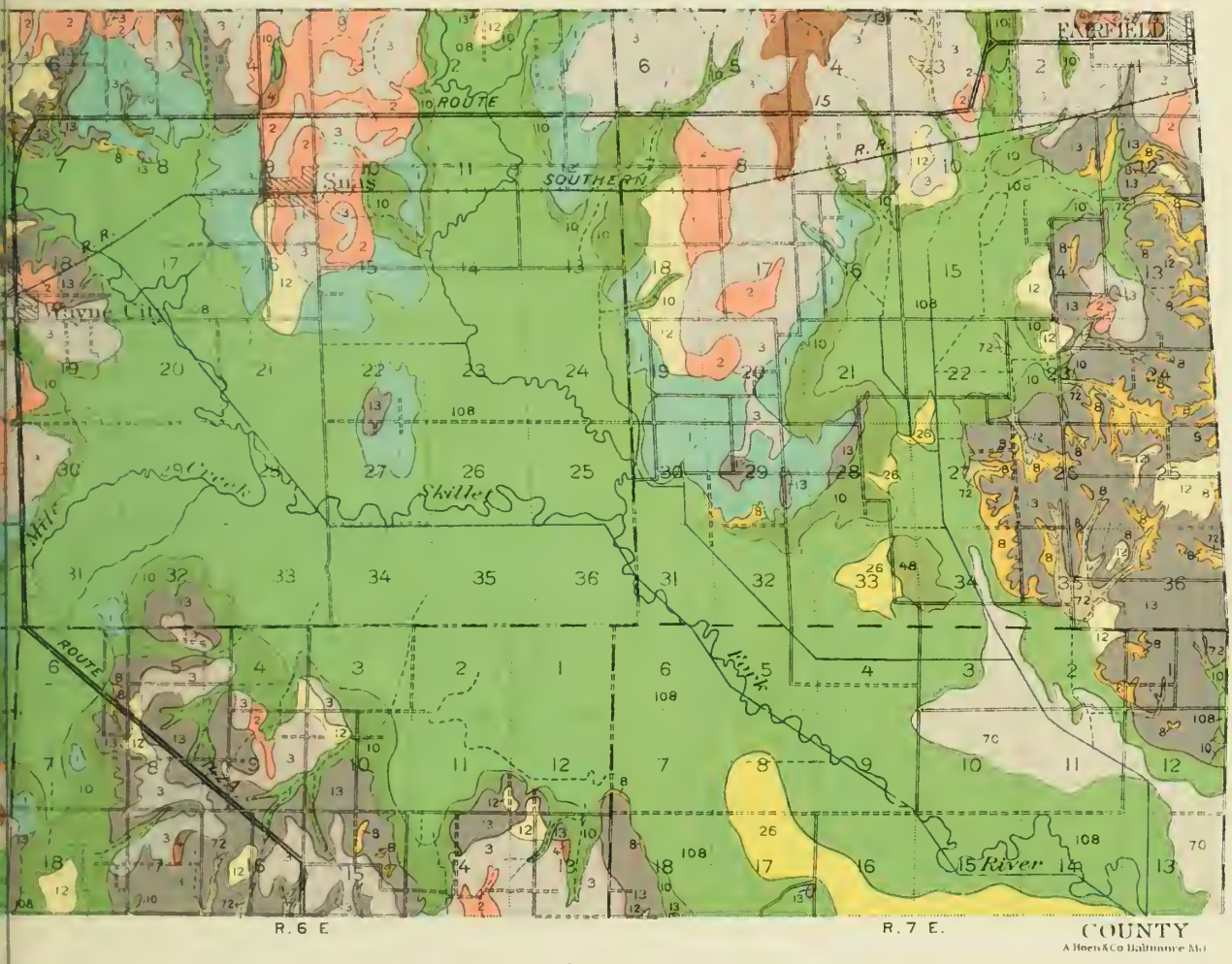


CONVENTIONAL SIGNS

- Swamps
- Small areas sandstone outcrop
- Railroads
- Public roads
- Private roads
- Township lines
- County lines
- Paved roads
- Levee

Scale
0 ¼ ½ 1 2 Miles

SC
UNIVERSIT



L SURVEY MAP OF WAYNE COUNTY

OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

Gray Silt Loam On Orange-Mottled Tight Clay (3)

Gray Silt Loam On Orange-Mottled Tight Clay is found on the undulating to gently rolling prairie land around the heads of stream drainage and on low ridges. It has fair surface drainage but poor underdrainage. It occupies 111.71 square miles, or over 15 percent of the total area of the county.

The surface soil is 6 to 7 inches thick, and is a friable, gray silt loam. The upper subsurface is yellowish gray in color, but in other respects is similar to the surface. The lower subsurface is a light gray, ashy silt loam, containing orange splotching near its base. The subsoil begins at 14 to 18 inches and is a compact, plastic, yellowish gray clay containing numerous orange-colored splotches. The lower subsoil, beginning at 28 to 30 inches, is less compact than the upper and contains some sand and small gravel. The lower subsoil is yellowish gray in color and has no orange-colored mottling.

Management.—This type occurs where there is sufficient slope for fair surface drainage, but the tight subsoil makes underdrainage poor. Ordinarily tile will not draw; so deep, open surface ditches must be used to drain the soil. After establishing drainage, organic-matter deficiencies should be taken care of as suggested above for Gray Silt Loam On Tight Clay. The results from the Fairfield experiment field (page 31), as well as those from a portion of the Ewing field (page 40), indicate that the use of a potassium fertilizer would pay. With proper management, fair crop yields can be expected from this type, but the nature of the subsoil limits the return in all but very favorable years.

Yellowish Gray Silt Loam On Orange-Mottled Tight Clay (4)

Yellowish Gray Silt Loam On Orange-Mottled Tight Clay occurs on rolling prairie land and is found scattered thruout the county on low knolls and ridges. This type occupies about 10 square miles in Wayne county. Most of the area was at one time covered with a growth of brush and scattering trees, such as locust and wild cherry.

The surface soil, which is 4 to 6 inches thick, is a grayish yellow silt loam. The subsurface is friable, yellow in color, with a dull red or orange mottling near the base. The subsoil begins at 11 to 14 inches and is a moderately compact and plastic clay loam. The color of the upper part of the subsoil is reddish yellow, heavily splotched with bright orange or red. The lower subsoil below 28 to 30 inches is somewhat sandy and gravelly and rather friable.

Management.—Surface water readily drains off this type because of the slope on which it is developed. Every precaution must be observed, however, to prevent erosion. If the land is to be continuously cultivated, it should be terraced and vegetation kept on it during winter and early spring months whenever possible. The soil is acid and is low in organic matter. Limestone should be applied and a legume, preferably sweet clover, seeded and the crop turned under. A phosphate fertilizer might be added, particularly if wheat is to be grown. This soil makes good orchard land and is well adapted to small fruits and vegetables. Alfalfa can be successfully grown following proper soil treatment. Winter wheat usually yields well, but the yield of corn is often cut by summer drouths.

Deep Gray Silt Loam (10)

Deep Gray Silt Loam occurs in depressions at the head of drainage basins and at the base of long, gradual slopes. Most of this type occurs as bench land between the gently sloping upland and the bottom land. It is closely associated with Deep Gray Silt Loam On Tight Clay but differs from it chiefly in receiving continuous deposits of silty material brought down in the run-off water from adjoining higher land. Flood waters frequently spread over the land after heavy rains, but only during extremely high flood stages does the water remain long.

The surface soil varies in thickness from 6 to 12 inches. It is a friable gray silt loam mixed with some sand and pebbles. The subsurface is lighter in color but in other respects is similar to the surface. The subsoil is more a continuation of the subsurface than a distinct subsoil, the soil material having been in position too short a time to develop a true subsoil. Occasionally a thin, pale yellowish gray, moderately compact layer occurs between 25 and 30 inches, at which depth is the beginning of subsoil development.

Management.—The suggestions given under Deep Gray Silt Loam On Tight Clay, page 14, may be consulted for the management of this type. Better drainage can be obtained by the use of tile and open surface ditches in this type than in the former tyye, which has developed a subsoil. This type, however, is subject to more frequent overflow. Crops planted late in the spring, such as corn, soybeans, or cowpeas, are better adapted to this type and should give a fair return if the land is properly managed.

Light Gray Silt Loam On Tight Clay (11)

Light Gray Silt Loam On Tight Clay occupies the very flat, exceptionally poorly drained areas in the upland that are now, or were formerly, covered by post oak and hickory timber. It is the poorest soil in the county but fortunately it covers only .17 square mile.

The surface soil before being plowed is only 2 to 3 inches thick and is a light gray silt loam. The subsurface is light gray to white in color, and the lower part is ashy. The subsoil is a thick, very compact and highly plastic, pale yellowish gray clay almost impervious to water.

Management.—It is practically impossible to drain this soil, and because of the drainage handicap it is doubtful whether any sort of treatment involving a money outlay should be attempted under present economic conditions. The land can best be kept in grass, such as redtop, and used for pasture or hay. Experiments on the Sparta experiment field, described on page 42, have shown some response to soil treatment, but the drainage at this location is somewhat better than that of the type in general. Moreover, even under the most favorable treatment, the level of production is still so low as to make the farming of this land a doubtful enterprise.

Yellow-Gray Silt Loam On Tight Clay (12)

Yellow-Gray Silt Loam On Tight Clay occurs on flat to very gently sloping land which is now, or was formerly, timbered with oak and hickory. It occupies

LEGEND

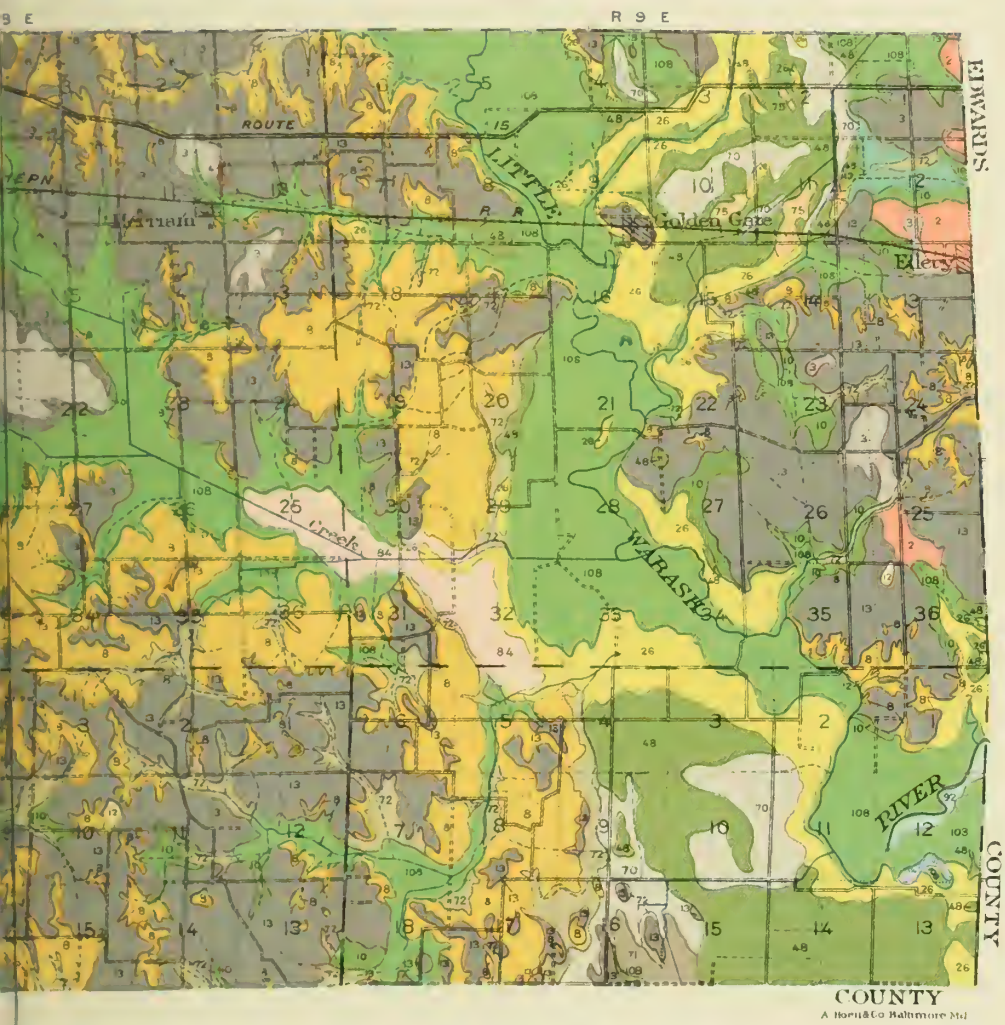
- 1 Deep Gray Silt Loam On Tight Clay
- 2 Gray Silt Loam On Tight Clay
- 3 Gray Silt Loam On Orange-Mottled Tight Clay
- 4 Yellowish-Gray Silt Loam On Orange-Mottled Tight Clay
- 10 Deep Gray Silt Loam
- 11 Light Gray Silt Loam On Tight Clay
- 12 Yellow-Gray Silt Loam On Tight Clay
- 13 Yellow-Gray Silt Loam On Compact Medium Plastic Clay
- 8 Eroded Gravelly Loam
- 72 Mixed Loam
- 48 Grayish Drab Silt Loam On Clay
- 26 Yellow-Gray Silt Loam On Clay
- 84 Gray Silt Loam On Clay
- 70 Drab Clay Loam
- 71 Drab Clay
- 75 Mixed Fine Sandy Loam
- 108 Deep Gray Silt Loam (Overflow)
- 92 River Sand

CONVENTIONAL SIGNS

- Swamps
- Small areas sandstone outcrop
- Railroads
- Public roads
- Private roads
- Township lines
- County lines
- Paved roads
- Levee

Scale
0 ¼ ½ 1 2 Miles

UNIVERSIT



L SURVEY MAP OF WAYNE COUNTY

OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

46.66 square miles, or 6.59 percent of the total area of the county. Both the surface drainage and underdrainage are naturally poor but not so bad as in Light Gray Silt Loam On Tight Clay. Slick spots occur frequently on this type, which in many respects resembles the type Gray Silt Loam On Tight Clay.

The surface soil, before being plowed, is 4 to 5 inches thick and is a friable, yellowish gray silt loam. The subsurface is light gray in its upper part and white and ashy in its lower part. The subsoil is a thick, very compact and plastic, pale yellowish gray clay almost impervious to water.

Management.—Since outlets are accessible surface drainage can usually be obtained thru the use of deep open surface ditches placed not too far apart. Under proper drainage this type can be treated so as to produce fair crops. The same suggestions given for the treatment of Gray Silt Loam On Tight Clay, page 15, apply to this type except that even more emphasis should be placed on increasing the organic-matter content. An account of field experiments at Raleigh will be found on page 43.

Yellow-Gray Silt Loam On Compact Medium-Plastic Clay (13)

Yellow-Gray Silt Loam On Compact Medium-Plastic Clay is found on the rolling upland that is now, or was formerly, timbered. It is well distributed thruout the county and covers more total area than any other one type, occupying 189.29 square miles, or about one-fourth of the area of the county. In the northern half of the county this type occupies a position between the flat prairie upland and the steep gullied land along streams. The intermediate slopes on which it occurs in this region were mostly produced by erosion. Practically all the smooth upland in the southeastern part of the county is included in this type and its sloping nature is due to the original, uneven, bed-rock surface which was not obliterated by the deposit of glacial drift. This type has good surface drainage and fair underdrainage.

The surface soil is 5 to 7 inches thick and is a grayish yellow silt loam. The upper subsurface is friable and yellow. On the more gentle slopes a shallow, ashy gray subsurface layer occurs, but on the more rolling land no gray layer is developed. The subsoil is a medium-compact and plastic, grayish-yellow clay loam on the gentle slopes, and a slightly compact, slightly plastic, silty clay loam on the more rolling land. The lower subsoil, below 28 to 35 inches, is friable and silty and contains some sand and small gravel.

Management.—Some artificial drainage must be provided on the less-sloping areas of this type. Tile will work if placed shallow in the ground and not over 3 to 4 rods apart. Open surface ditching is practical if care is observed to prevent erosion. Provision should be made to protect the more-rolling areas of this type from erosion. The land should have a protective cover of vegetation thruout the winter and spring months. Terracing would give good returns. When drainage is corrected and erosion stopped, organic matter should be added to the surface soil either as animal or as green manure. Sweet clover grows very well on this type after it is limed. A legume should be plowed under every three or four years to maintain the supply of organic matter. Trial applications of both a phosphorus and a potassium fertilizer are suggested. Some response in

crop yields should be obtained from these fertilizers after drainage and organic-matter deficiencies are corrected. This soil is adapted to a great variety of crops, including alfalfa, orchards, small fruit, vegetables, and common grains. It responds well to good farming, and under proper management should produce satisfactory crops.

Eroded Gravelly Loam (8)

Eroded Gravelly Loam is mapped on the steep gullied hillsides most of which lie adjacent to streams. It occupies 55.50 square miles in the county. All of this type is subject to seriously destructive erosion. Some of the area has not been cleared of its timber cover, and probably none of it should ever have been cleared for cultivation. When it was cleared, erosion soon made the land unfit for cultivation.

Eroded Gravelly Loam has had little or no true soil development because the surface material is removed faster than a soil forms. The material is a sandy, gravelly, clayey mass, and on steep slopes where erosion is very active it is calcareous.

Management.—Eroded Gravelly Loam should not be cultivated because erosion quickly removes the surface material. Some of the less-steep slopes can be used for orcharding or as pasture land. A vegetative cover should be kept on the surface at all times. This soil type should, for the most part, be kept in timber, or if cleared it should be replanted with trees and used for permanent pasture.

Mixed Loam (72)

Mixed Loam is mapped on the overflow land toward the heads of small streams. It occupies 12.58 square miles in Wayne county. The land is flooded following each heavy rain and receives a new deposit of material brought down from the surrounding upland. Because of frequent deposition a true soil profile is not developed. The soil material is composed of silt mixed with some sand and gravel. The surface soil, for a depth of 8 to 10 inches, is dark gray except at the base of steep slopes which continuously furnish yellow-colored sediment to the bottom land.

Management.—Most of the heavy rains that furnish flood-waters which overflow this type of soil come early in the season, so that a crop of corn, soybeans, or cowpeas can be matured on this land. Open surface ditches can be used to dry out the soil for cultivation in late spring. The soil is acid but unless clover is to be grown, limestone need not be applied. The frequent deposition of new material helps to keep up the fertility of this land.

Grayish Drab Silt Loam On Clay (48)

Grayish Drab Silt Loam On Clay is found in the southeastern part of the county in the bottom lands of Little Wabash river and Skillet Fork creek. It is subject to overflow but lies high enough so that floods seldom cover it, and when they do the water is shallow and soon withdraws. This type occupies 8.42 square miles in the county.

The surface soil varies from 7 to 9 inches in thickness and is a grayish drab, heavy silt loam. It is heavy enough to become cloddy if worked when wet. The subsurface is lighter in color but of about the same texture as the surface. It also contains numerous yellow splotches. The subsoil begins at 16 to 19 inches and is a medium-compact, drabbish gray clay loam splotched with pale yellow. The lower subsoil, below 28 to 32 inches, is a friable, yellowish gray clay loam.

Management.—This soil can be tile-drained; and if a proper outlet into a dredge ditch can be obtained, tile placed 6 to 8 rods apart will keep the excess water drained away. Of course during wet seasons and floods water will remain on the land because no outlet is afforded. The soil is sweet and will grow clovers without lime. A clover crop should be plowed under at least every fourth year to maintain the organic-matter supply, unless animal manure can be applied at the rate of 2 tons an acre a year. If wheat and clover are to be grown in the rotation, the application of a phosphate fertilizer should give increased yields. This is the most productive soil type in Wayne county, and if properly managed should return a profit on the investment. It is, however, subject to overflow and crops will occasionally be lost.

Yellow-Gray Silt Loam On Clay (26)

Yellow-Gray Silt Loam On Clay occurs in conjunction with the type just described, in the bottom lands in the southeastern part of the county. The area of this type is now, or was formerly, covered with timber. It is subject to overflow but can be readily drained. It occupies 7.69 square miles.

The surface soil is a grayish yellow, coarse silt loam. On a few scattered areas near the principal streams the surface is sandy, the sand being blown up from the lower lying land. The subsurface is a yellowish gray silt loam and on the flatter areas is an ashy, light gray silt loam. The subsoil begins at 15 to 19 inches and is a compact, plastic, yellowish gray clay loam heavily splotched with yellow. The lower subsoil is friable and is yellow in color.

Management.—Drainage can be taken care of as suggested for Grayish Drab Silt Loam On Clay, discussed above. Provision must be made to supply organic matter thru either animal or green manures. The surface soil is somewhat acid, and limestone must be applied if clover is to be grown. If further treatment is to be attempted, a trial application of both a phosphorus and a potassium fertilizer is suggested. This soil is moderately productive and will produce the common grain crops grown in the region.

Gray Silt Loam On Clay (84)

Gray Silt Loam On Clay occurs in the bottom land of Little Wabash river and Skillet Fork creek. It is subject to frequent overflow, and has received a deposit of silt over a heavy clay loam. It is naturally poorly drained because of its flat, low-lying position.

The surface soil is a drabbish gray silt to silty clay loam and is about 6 to 8 inches thick. In depressions, the surface soil is darker and heavier than in surrounding areas. The subsurface is grayer than the surface and somewhat heavier. The subsoil is a light drabbish gray, compact, plastic clay.

Management.—Drainage can be obtained by open surface ditches leading into a dredge ditch or stream. Short strings of tile can be used to drain depressions on the flat surface. For further recommendations as to management for this soil type, the reader is referred to the suggestions given above for Yellow-Gray Silt Loam On Clay. If good drainage can be obtained, this soil can be managed so as to become moderately productive; otherwise it is usually so late in summer before a crop can be put on the land that there is not enough time left to mature the crop. Corn is the chief crop grown, but not much of this type of soil is cropped.

Drab Clay Loam (70)

Drab Clay Loam occurs in the large bottom land in the southeastern part of the county. It occupies 5.87 square miles. It is found on low-lying, originally swampy land which has been drained by dredge ditches and is now cultivated. The soil material making up this type was deposited largely out of quiet water and is therefore of a fine texture.

The surface soil is a brownish drab, plastic clay loam. The subsurface is a grayish drab, very plastic clay. The subsoil begins at 15 to 18 inches and is a heavy, very plastic, pale yellowish gray clay.

Management.—Good drainage is difficult to obtain in Drab Clay Loam because water does not move readily thru it. Deep ditches and liberal use of tile will remove the water but it will take considerably longer than in other soil types. Care must be taken not to plow the land when it is too wet, for it is difficult to work up a good seed bed on cloddy ground. Animal and green manures must be turned under frequently lest the physical condition of the soil become so bad that it cannot be successfully cultivated. The soil is sweet, and clovers will grow without lime. Some legume crop should be grown and turned under every three years. This soil will produce a good crop of corn in favorable years if properly treated, but it is frequently impossible to get a crop planted because of too much moisture.

Drab Clay (71)

Drab Clay occurs in low-lying, depressed areas in conjunction with Drab Clay Loam. It occupies only half a square mile. It is similar to Drab Clay Loam except that it is heavier in texture and thus more difficult to drain and to cultivate.

Management.—The suggestions given above for Drab Clay Loam apply also to this type, but because of greater drainage difficulties fewer crops can be harvested.

Mixed Fine Sandy Loam (75)

Three small areas of Mixed Fine Sandy Loam are found in the bottom land of Little Wabash river just east of the town of Golden Gate. The type occupies only 154 acres. It lies on a slightly elevated position, the fine sandy material having been transferred by wind from the surrounding bottom land.

The surface soil is a yellowish gray, loose, fine sandy loam. The subsurface is lighter in color and is less sandy than the surface. The subsoil is a compact, plastic, yellowish gray clay loam containing enough fine sand to make it gritty. The subsoil begins at depths of 14 to 18 inches. On the more undulating ridges the material is more sandy, is yellow instead of gray, and there is less compaction in the subsoil.

Management.—This type is well drained and does not overflow except at extremely high flood stage. The soil is acid and needs organic matter. Because of its drouthy nature it is better adapted to special crops such as vegetables and melons than to corn. For further recommendations for this type the reader is referred to the management suggested for Yellow-Gray Silt Loam On Clay, page 21.

Deep Gray Silt Loam (108)

Deep Gray Silt Loam is the predominating bottom-land type in Wayne county. It occupies altogether about 170 square miles, or nearly one-fourth of the total area of the county. The material forming it is largely silt brought down in overflows from upstream and surrounding uplands. The bottom lands being flat, poorly drained, and often swampy, the material has been kept under high moisture conditions most of the time. The soil has not developed to any extent because it is continuously receiving a new deposit thru overflow.

The surface soil, varying from 6 to 10 inches in thickness, is a gray silt loam. Below the surface the material is lighter in color and is silty. Some sand and small pebbles are scattered thruout the soil. On the higher areas, which seldom overflow, a light gray subsurface and a thin, pale yellowish gray, compact and plastic subsoil have formed.

Management.—Drainage must be provided if this soil is to be cropped, for it seldom dries out before midsummer. Surface ditches can be used for drainage if an outlet can be obtained. The soil is somewhat acid and needs organic matter. If it can be drained and does not overflow too often, limestone should be applied and sweet clover grown and turned under. Corn is the principal crop on this type because the soil usually dries out early enough to plant the crop and seldom overflows until after the corn is harvested in the fall. Most of the land is not cropped, however, but is either used for pasture or allowed to remain idle.

River Sand (92)

River Sand, as the name implies, is a sandy formation developed from the deposition of material out of swiftly moving water. It occurs near the river bank. Only 109 acres are mapped as this type in Wayne county. The material is largely yellow sand and no soil development is apparent.

Management.—This type overflows frequently. It is drouthy and cannot be successfully used for grain crops. Melons and other truck and vegetable crops can often be grown on it with profit.

CHEMICAL COMPOSITION OF WAYNE COUNTY SOILS

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore, it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires

TABLE 2.—WAYNE COUNTY SOILS[1]: PLANT-FOOD ELEMENTS IN THE UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
1	Deep Gray Silt Loam On Tight Clay	25 110	2 530	730	440	24 490	4 940	5 070
2	Gray Silt Loam On Tight Clay	28 400	2 890	780	540	24 300	4 240	4 650
3	Gray Silt Loam On Orange-Mottled Tight Clay	27 130	2 700	750	450	24 050	4 200	4 060
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay	34 280	3 290	700	580	26 950	5 700	4 450
10	Deep Gray Silt Loam	18 680	2 060	800	400	28 380	3 500	4 220
11	Light Gray Silt Loam On Tight Clay	19 520	2 020	620	300	21 300	4 100	4 400
12	Yellow-Gray Silt Loam On Tight Clay	21 850	2 040	800	480	24 360	3 880	3 920
13	Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	23 240	2 205	760	440	27 770	5 140	4 240
8	Eroded Gravelly Loam[2]	.....	.....	.....	.....	.....	.....	.....
72	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....
48	Grayish Drab Silt Loam On Clay[3]	.....	.....	.....	.....	.....	.....	.....
26	Yellow-Gray Silt Loam On Clay	25 390	2 210	870	350	33 360	6 840	6 880
84	Gray Silt Loam On Clay	24 580	1 900	600	(4)	26 080	5 140	2 360
70	Drab Clay Loam	35 820	3 270	1 250	490	39 850	10 980	12 900
71	Drab Clay	100 460	8 420	2 400	1 220	34 680	15 980	24 440
75	Mixed Fine Sandy Loam[2]	.....	.....	.....	.....	.....	.....	.....
108	Deep Gray Silt Loam (overflow)[2]	.....	.....	.....	.....	.....	.....	.....
92	River Sand[2]	.....	.....	.....	.....	.....	.....	.....

[1]Data based upon samples taken in neighboring counties. [2]The results of chemical analyses of Types 8, 72, 75, 92, and 108 are not included because of the heterogeneous character of these soils. [3]No samples were obtained representing Type 48. [4]Sample exhausted.

to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as explained above. The figures for the middle and lower strata must therefore be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

The data presented in Tables 2, 3, and 4 show the amounts of various plant-food elements in Wayne county soils as based upon analyses of samples taken from the same soil types in neighboring counties.

Most Types Deficient in Organic Matter and Nitrogen

The surface soil of farm lands in Wayne county contains, on the average, less than 30,000 pounds of organic carbon to the acre, with the exception of Types 4, 70, and 71 (Table 2). As the organic matter of soil is approximately half carbon, the actual organic matter may be considered as double the figures given for organic carbon. Soil nitrogen is nearly all combined in the organic matter; consequently this element varies fairly regularly with the carbon, being present in the surface soil in amounts one-ninth to one-tenth as large as those of carbon. The average ratio of nitrogen to carbon in Wayne county soils is 1 to 10.6. The ratio is much wider than this in fresh organic materials but, as decay proceeds, the carbon is oxidized and lost more rapidly than is the nitrogen

TABLE 3.—WAYNE COUNTY SOILS[1]: PLANT-FOOD ELEMENTS IN THE MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
1	Deep Gray Silt Loam On Tight Clay	32 870	3 100	1 230	680	49 360	10 750	8 650
2	Gray Silt Loam On Tight Clay	28 510	3 310	1 170	780	52 080	9 190	8 060
3	Gray Silt Loam On Orange-Mottled Tight Clay	28 520	3 300	1 230	600	52 320	10 980	7 260
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay	38 410	4 250	1 250	760	58 190	16 130	7 530
10	Deep Gray Silt Loam	24 600	2 680	1 400	560	57 880	9 360	9 800
11	Light Gray Silt Loam On Tight Clay	23 520	2 520	1 040	400	42 880	7 760	8 080
12	Yellow-Gray Silt Loam On Tight Clay	16 330	2 220	1 340	730	52 380	11 600	6 370
13	Yellow-Gray Silt Loam On Compact Medium Plastic Clay	20 890	2 360	1 410	530	60 390	14 130	7 270
8	Eroded Gravelly Clay[2]	.....	.....	.....	.....	.....	.....	.....
72	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....
48	Gravish Drab Silt Loam On Clay[3]	.....	.....	.....	.....	.....	.....	.....
26	Yellow-Gray Silt Loam On Clay	21 120	2 310	1 240	440	71 510	19 280	14 160
84	Gray Silt Loam On Clay	17 480	1 600	880	[4]	53 360	10 440	5 000
70	Drab Clay Loam	40 160	3 960	1 800	600	79 620	22 830	23 970
71	Drab Clay	91 040	8 200	6 360	1 160	68 080	30 880	50 080
75	Mixed Fine Sandy Loam[2]	.....	.....	.....	.....	.....	.....	.....
108	Deep Gray Silt Loam (overflow)[2]	.....	.....	.....	.....	.....	.....	.....
92	River Sand[2]	.....	.....	.....	.....	.....	.....	.....

[1]Data based upon samples taken in neighboring counties. [2]The results of chemical analyses of Types 8, 72, 75, 92, and 108 are not included because of the heterogeneous character of these soils. [3]No samples were obtained representing Type 48. [4]Sample exhausted.

TABLE 4.—WAYNE COUNTY SOILS[1]: PLANT-FOOD ELEMENTS IN THE LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
1	Deep Gray Silt Loam On Tight Clay	29 680	3 350	1 520	780	76 690	24 380	15 190
2	Gray Silt Loam On Tight Clay	21 710	3 230	2 050	840	82 830	28 150	18 970
3	Gray Silt Loam On Orange-Mottled Tight Clay	23 660	3 390	1 830	660	80 490	24 290	13 880
4	Yellowish Gray Silt Loam On Orange-Mottled Tight Clay	28 180	3 580	1 800	1 140	91 140	34 920	17 460
10	Deep Gray Silt Loam	29 340	3 780	1 920	960	88 860	16 680	13 140
11	Light Gray Silt Loam On Tight Clay	18 780	3 000	1 500	480	66 780	20 640	12 900
12	Yellowish Gray Silt Loam On Tight Clay	13 020	2 110	1 760	860	83 210	28 460	13 450
13	Yellow-Gray Silt Loam On Compact Medium Plastic Clay	18 930	2 420	1 880	510	92 770	25 610	13 885
8	Eroded Gravelly Loam[2]	.....	.....	.....	.....	.....	.....	.....
72	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....
48	Grayish Drab Silt Loam On Clay[3]	.....	.....	.....	.....	.....	.....	.....
26	Yellow-Gray Silt Loam On Clay	31 920	3 230	2 400	580	118 350	56 240	58 100
84	Gray Silt Loam On Clay	21 960	2 160	1 440	(4)	84 840	22 500	8 340
70	Drab Clay Loam	33 480	3 810	2 280	680	120 230	40 080	34 880
71	Drab Clay	89 820	7 560	(4)	1 500	97 200	39 000	61 380
75	Mixed Fine Sandy Loam[2]	.....	.....	.....	.....	.....	.....	.....
108	Deep Gray Silt Loam (overflow)[2]	.....	.....	.....	.....	.....	.....	.....
92	River Sand[2]	.....	.....	.....	.....	.....	.....	.....

[1]Data based upon samples taken in neighboring counties. [2]The results of chemical analyses of Types 8, 72, 75, 92, and 108 are not included because of the heterogeneous character of these soils. [3]No samples were obtained representing Type 48. [4]Sample exhausted.

and consequently the ratio narrows gradually with age. Thus very young soils frequently have nitrogen-carbon ratios as wide as 1 to 14 or even wider.

Calculations from Tables 3 and 4 reveal that the ratio of nitrogen to carbon grows more narrow with increasing depth of soil, the average for the middle stratum being 1 to 9.4, and for the lower stratum 1 to 8.3 with a minimum of 1 to 6.2 in a single type (Type 12). The narrowing of this ratio with increasing depth is more pronounced in the more-mature soil types mainly because the organic matter in the deeper levels is older and is replenished with fresh vegetable matter to a less extent than is that nearer the surface.

Phosphorus and Sulfur Less Closely Associated With Organic Matter

Two other chemical elements, phosphorus and sulfur, both essential for plant growth, are associated with the organic matter of the soil, tho to a less extent than is nitrogen. From one-fourth to one-third of the total phosphorus in mineral soils exists as organic phosphorus as a rule. The proportion is higher in soils high in organic matter, and hence in such soils a closer relationship between the two may be observed. In soils at the organic-matter level of the majority of the Wayne county types, the organic phosphorus constitutes probably less than one-fourth of the total phosphorus. In the surface soils of this county the sulfur content averages about 60 percent as high as that of phosphorus. The proportion of sulfur decreases to about 40 percent as much as the

phosphorus in the lower sampling stratum. Type 71, which is richer in organic matter than any other type in the county, has also the highest proportion of both phosphorus and sulfur. The amounts of these elements, however, do not run entirely parallel to each other or to the organic carbon thruout all the types.

While crops in general take as much sulfur as phosphorus from the soil, sulfur deficiencies do not ordinarily develop because of constant renewals from the atmospheric supply. Sulfur dioxid, which escapes into the air in the burning of wood and coal, is brought to the earth dissolved in rain water. The amount added ranges in different parts of the state from one to three or more pounds of sulfur an acre a month.

Potassium Content Comparatively Uniform

The potassium content of the soils of Wayne county varies less from type to type than is the case with the other chemical elements. The mean potassium content in the plowed soil amounts to approximately 25,000 pounds an acre, with the exception of three types, Nos. 26, 70, and 71, which contain considerably more. In all the types the potassium concentration found in the plowed soil is maintained essentially without change thruout the 40 inches sampled.

Wide Variations in Calcium and Magnesium

The variations in the calcium and magnesium content of Wayne county soils are almost as great as those in the organic matter. These two elements, particularly calcium, are of special interest because of the relation which they bear to the lime-requirement of soils.

Aside from the calcium which may be in solution in the soil water, soil calcium exists primarily in three forms. *Calcium-aluminum silicates* are complex soil minerals which decompose slowly and furnish but scant amounts of soluble calcium for plant growth. This is the form which predominates in most soils, particularly those which are highly acid. Available calcium may be deficient for plant growth in such soils, so that the supplying of this element in readily available form may be one of the benefits of liming. Calcium also occurs in association with the soil colloids (the finest of the clay particles), by which it is absorbed; this is known as *replaceable calcium,* and is much more easily obtainable by growing plants than the mineral form mentioned above. It is found more abundantly in the soils which are nonacid or only slightly acid. Types are occasionally found that grow sweet clover luxuriantly because of the high degree of saturation of their colloids with replaceable calcium, even tho they may be actually somewhat acid. *Calcium carbonate,* the form contained in limestone, is the third form of calcium in soils. It occurs only in alkaline (sweet) soils. Of the three forms of calcium this is the most readily dissolved in the soil water and removed in the drainage water to lower and lower levels as leaching proceeds. The extent of this process in Wayne county has been such that all the calcium carbonate has been removed from the surface stratum and, in nearly all of the soils, to a depth greater than the 40 inches represented in the sampling.

Even after the carbonates have disappeared, there continues a gradual release of the replaceable calcium and magnesium, which are partly taken up by growing

crops but which are also continually being carried downward by the soil water. This removal goes on at very different rates for the two elements. Either because of the more rapid leaching out of replaceable calcium, or a reabsorption of magnesium by the soil colloids, the proportionate amount of magnesium as compared with calcium increases with increasing depth. This changing ratio of magnesium to calcium in the lower levels is a function of the ageing, or approaching maturity, of the soil. It is very pronounced in mature types but occurs to only a slight extent, or not at all, in young or immature soils.

For example, it may readily be computed from the calcium and magnesium data of Tables 2, 3, and 4 that in one of the mature types, such as Type 12, the magnesium-calcium ratios are, for the upper, middle and lower strata, respectively, .99, 1.82, and 2.12. That is, the two elements are present in equal amounts in the surface soil, but in the lower level there is 2.12 times as much magnesium as calcium. On the other hand, in an immature type such as Drab Clay the ratios are not only low but they are about the same in all three depths, namely, .65, .62, and .64.

From these observations it is obvious that some of the processes involved in soil development are definitely reflected in the chemical properties of the soil itself. These, in turn, are related to agricultural utilization and fertility requirements.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or the acidity of a given soil type because, while some samples will contain calcium in the form of carbonate (few if any such areas are to be found in Wayne county), others not only will contain none but may actually have a lime requirement due to soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made during the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and they give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests therefore furnish the basis for some general recommendations given in the descriptions of individual types on pages 14 to 23. To have a sound basis for the application of limestone the owner or operator of a farm will usually find it desirable to determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 49) is pertinent in this connection.

Character of Chemical Combination Related to Availability

It has been seen that a given plant-food element exists in the soil in various forms, or chemical combinations. Thus soil phosphorus is found partly in organic form and partly in inorganic, or mineral, combinations. These forms

differ from each other, not only in the rates at which they become available to growing crops, but also in the way in which their availability to crops is affected by soil conditions. Calcium, for example, has been observed to be present sometimes as *calcium carbonate,* a form that is quickly available to crops; sometimes as *replaceable calcium,* a form somewhat less active than calcium carbonate; and also as *calcium-alumino-silicates,* minerals that decompose very slowly. Statements of similar import might be made concerning nitrogen, sulfur, and other elements. Moreover, the proportions in which the different forms of an element occur vary in different soils.

Thus, the rate at which plant-food elements become available is extremely important; a knowledge of merely the total amounts of these various elements present in a soil does not furnish sufficient information for complete guidance for the application of fertilizers.

Service of Chemical Investigations in Soil Improvement

While the chemical investigations carried out in connection with the soil survey (of which the analyses here reported are a part) may not all serve directly as a complete guide in the use of fertilizers, they are nevertheless of special value in two ways.

In the first place such investigations reveal at once any *outstanding* deficiencies in the amounts of the various plant-food elements present—deficiencies so large that soil productivity would be affected regardless of other conditions. For instance, peat soils usually lack sufficient potassium to grow crops. This condition is revealed at once by the chemical analysis and the proper corrective measure is obvious. Small differences in the amount of a plant-food element, however, do not necessarily indicate similar differences in fertilizer need. Differences in phosphorus content as small as 100 or 200 pounds an acre, for example, should not be considered as indicating similar differences in the need for phosphate fertilization. In the case of nitrogen ordinary chemical analysis does not distinguish between active and inactive forms. One hundred pounds of active nitrogen added by plowing down a clover crop may be of more importance to the succeeding crop than 1,000 pounds of soil nitrogen if only a small part of it happens to be in a form that plants can use.

As examples of the direct use of chemical analysis in soil improvement may be cited the tests for soil acidity, for carbonate, and for available phosphorus.

The second use of chemical methods is in the more detailed study of soils. The processes of soil development leave their imprint upon the soil both in its physical conformation and in its chemical characteristics. Likewise every operation in the handling of the soil and every application of fertilizer or liming material disturbs its equilibrium, setting up new reactions, which are in turn reflected in variations in crop adaptability, producing capacity, and agricultural usefulness. Chemistry is a most important tool in tracing and characterizing such changes. Chemical investigations are undertaken, therefore, with the aim of aiding in the classification of soils as well as making possible more accurate prediction of their agricultural value and fertility needs and their response to different methods of management.

FIELD EXPERIMENTS ON SOIL TYPES SIMILAR TO THOSE IN WAYNE COUNTY

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the results from certain of these fields located on soil types described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields. The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems. On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations. Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment. The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used. In the presentation of the data much use is made of the following symbols:

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated, (sP = superphosphate, bP = bone meal, rP = rock phosphate, slP = slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

FAIRFIELD FIELD

An experiment field in Wayne county near Fairfield was maintained by the University of Illinois for nineteen years. The work was discontinued in 1923. The field was established primarily for crop-improvement investigations relating to such matters as methods of seeding, cultivation, care, and handling, and varietal tests of our common field crops. The plots were kept under what was considered a good practical system of soil treatment, with certain untreated check plots left for comparison. Only those experiments that had to do directly with soil treatments will be considered here; the results of the strictly crop-improvement experiments have been presented in other publications.

The field was located in about the center of the northwest quarter of Section 36 of Lanard township, on land characteristic of most of the level prairie region in the northern part of Wayne county. The soil is light in color and strongly acid. Altho, according to the county map, two soil types appear—Gray Silt Loam On Tight Clay and Gray Silt Loam On Orange-Mottled Tight Clay—the differentiation between the two types as they occur here is not sharply defined, one merging into the other.

The field included 40 acres and was laid out in four series of plots, each series representing a cropping unit in a rotation system. A system of tile drainage was installed in the north section of each series so that all plantings were duplicated on land tile-drained and not tile-drained.

A four-year rotation of corn, cowpeas or soybeans, wheat, and clover was employed. When clover failed, which happened in several years, soybeans or

TABLE 5.—FAIRFIELD FIELD: ANNUAL CROP YIELDS

Bushels or (tons) per acre

Series 100

Soil treatment[1]	1905 Corn	1906 Soy-beans	1907 Wheat	1908 Clover	1909 Corn	1910 Soy-beans	1911 Wheat	1912 Clover	1913 Corn	1914 Soy-beans	1915 Wheat	1916 Soy-beans[2]	1917 Corn	1918 Soy-beans	1919 Wheat	1920 Sweet clover	1921 Corn	1922 Soy-beans	1923 Wheat
Land tile-drained																			
RLP	35.0	1.2	15.4	(1.02)	32.5	20.9	14.7	.35	2.3	12.4	7.6	19.4	47.4	14.9	23.4	1.75	41.0	10.1	13.3
R	51.3	1.4	11.8	(.90)	48.5	18.5	4.8	.15	11.4	10.4	0	13.7	65.3	12.5	8.7	0	30.8	8.4	2.8
MLP	62.3	1.5	18.9	(1.39)	40.3	(2.10)	26.0	(2.19)	3.8	(1.20)	5.1	(1.60)	59.0	(1.63)	26.0	(1.63)	47.8	[3]	21.6
M	57.0	1.4	3.8	(.65)	39.4	(1.54)	5.3	(.70)	7.1	(.77)	0	(0)	41.8	(.97)	10.5	(.84)	33.6	[3]	3.9
Land not tile-drained																			
RLP	27.5	1.3	10.8	(1.11)	31.6	20.2	7.7	.39	2.3	14.1	1.7	14.6	34.6	13.1	20.1	13.1	20.8	8.3	10.5
R	13.1	0	0	(.67)	17.7	10.3	.7	0	1.8	6.4	0	2.3	7.5	6.0	0	5.4	15.2	5.0	.1
MLP	59.4	.7	13.2	(1.68)	33.5	(1.79)	14.5	(1.72)	1.9	(1.03)	1.7	(1.33)	43.8	(1.35)	27.3	(1.22)	43.4	[3]	20.0
M	47.0	0	1.5	(.63)	18.7	(1.02)	.7	(.34)	3.7	(.51)	0	(0)	13.0	(.79)	0	(.53)	25.3	[3]	.3

Series 200

Soil treatment[1]	1905 Soy-beans	1906 Wheat	1907 Clover[4]	1908 Corn	1909 Cow-peas	1910 Wheat	1911 Clover	1912 Corn	1913 Soy-beans	1914 Wheat	1915 Soy-beans	1916 Corn	1917 Soy-beans	1918 Wheat	1919 Sweet clover	1920 Corn	1921 Soy-beans	1922 Wheat	1923 Sweet clover
Land tile-drained																			
RLP	2.7	1.3	(.50)	22.3	3.9	29.7	0	39.4	13.4	14.6	17.1	11.0	12.8	24.3	....	27.6	13.0	19.3	[6]
R	3.3	.3	(.20)	28.5	8.3	20.2	0	22.3	9.8	8.8	11.8	20.7	11.6	25.1	....	33.3	12.9	11.3	[6]
MLP	1.8	2.4	(.84)	37.2	6.7	37.5	(.99)	57.6	(1.06)	21.6	(1.85)	9.7	(1.35)	29.3	(1.05)	46.9	(1.67)	25.3	(1.72)
M	1.6	1.2	(.51)	37.9	8.4	20.9	(.41)[5]	22.3	(.92)	12.3	(1.01)	16.9	(1.13)	29.2	(.70)	36.9	(1.21)	17.5	(0)
Land not tile-drained																			
RLP	2.8	2.0	(.78)	26.1	4.8	30.1	0	18.6	11.8	13.7	12.8	13.1	9.9	21.0	....	13.7	9.7	20.0	[6]
R	2.2	0	(.61)	15.6	3.8	7.2	0	1.6	7.8	.6	5.9	14.0	8.8	11.1	....	18.7	7.8	1.2	[6]
MLP	1.9	3.2	(1.03)	39.3	7.4	36.0	(.85)	22.9	(1.19)	18.3	(2.03)	17.6	(1.40)	21.5	(1.26)	45.5	(1.60)	24.0	(1.75)
M	1.6	1.6	(.66)	30.2	6.4	16.4	(.39)[5]	4.0	(.71)	2.7	(.72)	11.9	(.70)	11.3	(.67)	27.1	(1.06)	1.9	(0)

[1]Potassium sulfate and kainit applied to different parts of each plot, as explained on page 37. [2]Sweet clover on manure plots in 1916. [3]Weight lost before recording. [4]Growth mostly redtop. [5]Grass and weeds. [6]No seed harvested.

TABLE 5.—*Concluded*

Series 300

Soil treatment[1]	1905	1906 Clover	1907 Corn	1908 Cow-peas	1909 Oats	1910 Clover	1911 Corn	1912 Soy-beans	1913 Wheat	1914 Soy-beans	1915 Corn	1916 Soy-beans	1917 Wheat	1918 Sweet clover	1919 Corn	1920 Soy-beans	1921 Wheat	1922 Sweet clover	1923 Corn
Land tile-drained																			
RLP	....	(.12)	39.0	7.7	35.9	1.45	34.6	(1.69)	14.3	17.3	44.1	7.5	23.8	2.05	32.7	13.1	24.0	[3]	21.5[4]
R	....	(.10)	32.1	4.7	25.8	0	25.9	(.53)	.6	7.3	24.9	6.3	5.5	0	19.1	7.9	4.5	[3]	22.0
MLP	....	(.44)	49.5	11.5	37.3	(3.95)	38.2	(2.17)	22.8	(1.55)	47.0	(1.02)	32.3	(1.45)	36.2	(1.46)	34.7	(2.19)	34.9
M	....	(.25)	35.3	5.4	30.8	(.76)[2]	30.5	(1.29)	3.1	(.87)	26.6	(.90)	14.0	(0)	27.1	(.87)	15.8	(0)	30.0
Land not tile-drained																			
RLP	....	(.50)	45.4	9.0	35.7	1.96	36.6	(1.72)	15.5	14.3	49.1	7.7	33.5	1.12	26.3	11.2	29.2	[3]	12.8[4]
R	....	(.20)	34.2	5.3	29.9	0	24.2	(.97)	2.2	10.0	30.1	7.4	13.0	0	11.5	10.5	6.5	[3]	18.1
MLP	....	(.48)	52.4	9.4	40.0	(3.70)	31.4	(2.10)	15.8	(1.63)	46.1	(1.02)	30.7	(1.01)	34.6	(1.29)	32.4	(2.22)	26.0
M	....	(.39)	42.1	7.4	34.2	(1.06)[2]	31.8	(.99)	3.2	(1.11)	36.5	(.82)	17.3	(0)	21.0	(.94)	16.6	(0)	28.2

Series 400

Soil treatment[1]	1905	1906 Corn	1907 Cow-peas	1908 Wheat	1909 Cow-peas	1910 Corn	1911 Soy-beans	1912 Wheat	1913 Soy-beans	1914[5] Corn	1915 Soy-beans	1916 Wheat	1917 Soy-beans	1918 Corn	1919 Soy-beans	1920 Wheat	1921 Sweet clover	1922 Corn	1923 Soy-beans
Land tile-drained																			
RLP	....	36.5	3.3	15.0	6.1	58.0	11.5	12.9	10.2	....	19.1	12.6	9.0	18.8	8.0	15.0	1.21	35.1	13.0
R	....	32.6	3.2	5.3	7.2	44.4	11.5	1.7	9.9	....	7.6	0	6.2	20.0	5.7	0	0	24.3	9.7
MLP	....	50.0	8.0	21.6	6.6	65.9	15.0	13.2	(.89)	....	(1.84)	28.9	(1.39)	19.4	(1.03)	23.2	(1.43)	36.6	(2.03)
M	....	41.6	3.4	10.6	6.9	43.8	10.2	2.1	(.65)	....	(.77)	.3	(.95)	16.6	(.53)	.5	(0)	20.8	(1.30)
Land not tile-drained																			
RLP	....	42.9	5.2	12.5	5.3	59.3	12.6	11.7	12.2	....	13.7	13.0	8.8	18.1	9.4	14.0	1.58	26.3	14.1
R	....	33.0	1.8	2.8	6.5	37.6	9.1	1.0	7.5	....	4.5	0	4.9	7.8	3.8	0	0	12.8	8.6
MLP	....	50.9	5.5	15.7	5.4	64.4	13.1	12.0	(.86)	....	(1.89)	25.4	(1.33)	9.4	(.92)	21.6	(1.79)	25.5	(2.07)
M	....	40.3	2.2	1.4	5.4	47.5	8.8	1.1	(.55)	....	(.62)	0	(.83)	5.1	(.48)	0	(0)	15.3	(1.25)

[1]Potassium sulfate and kainit applied to different parts of each plot, as explained on page 37. [2]Mostly grass and weeds. [3]Growth plowed down. [4]Chinch-bug injury. [5]Crop failure.

cowpeas were substituted. In the later years of the experiments sweet clover was introduced as the regular legume.

The crops were handled under the two general systems of farming, grain and livestock, a portion of the plots receiving stable manure and another portion crop residues instead of manure, as explained on pages 30 and 31.

In both these systems limestone and rock phosphate were applied in addition to the organic manures, but check plots were reserved which received either manure alone or residues alone.

In addition to these treatments potassium fertilizers were applied across one half of all plots in the manner described below. These applications were continued from 1907 to 1915. On the assumption that little effect would be exerted on the other crops, yields from the potassium treatments were measured only on the corn and clover, as described below. Altho this introduces an error that cannot be exactly determined, it is believed that the effects from the treatments other than potassium are, on the whole, so outstanding as to render the results of interest and that certain comparisons may be safely made in spite of the presence of this uncertain minor error.

A record of the yields of all crops grown during the time of these experiments is given in Table 5. For convenience in making comparisons, the results for the corn, wheat, and soybean crops are summarized in Table 6 in the form of average annual yields for the years after the complete treatments had come into effect. The clover yields were so few and so irregular that there seems to be no advantage in attempting to summarize them.

Results Under Manure and Residues Systems

A glance at Table 6 gives some idea of the cropping possibilities of this land. Under the most favorable treatment corn yielded an average of more than 36 bushels an acre. Wheat made nearly 25 bushels, and soybeans yielded over 1½ tons of hay. On the other hand, under the least favorable treatment the corn

TABLE 6.—FAIRFIELD FIELD: SUMMARY OF CORN, WHEAT, AND SOYBEAN YIELDS
Average annual yields 1909-1923—Bushels (or tons) per acre

Soil treatment[1]	Corn *15 crops*	Wheat *14 crops*	Soybeans *18 seed crops* *15 hay crops*
Land tile-drained			
RLP	30.3	17.8	13.4
R	27.5	6.7	10.1
MLP	36.2	24.8	(1.55)
M	26.2	9.7	(.99)
Land not tile-drained			
RLP	24.8	17.2	12.1
R	14.6	3.1	7.0
MLP	29.7	21.5	(1.49)
M	19.3	5.1	(.82)

[1]A portion of all plots received some potassium applications as explained in accompanying text.

yielded only 14.6 bushels an acre, wheat about 3 bushels, and soybeans 7 bushels. It should be borne in mind that these figures represent averages only, and averages never tell the whole story—there are the "lean" years as well as the "fat" years to be considered when results differ widely from the ordinary. For example, during four of the fifteen years recorded here corn on well treated land yielded less than 20 bushels an acre.

It is of interest to note that the combination of manure, limestone, and rock phosphate proved to be the most effective soil treatment. It is also of interest to note that manure alone was incapable of producing profitable yields. The experiments provided no means of separating the effects of limestone and of rock phosphate. It is probable, however, that limestone played the major role in producing the increased yields.

Effect of Tile-Drainage

In order to observe the effect of tile-drainage on this land, the yields of the respective crops as shown in Table 6 are compared for each soil treatment on the tiled and untiled plots.

Before considering these results, it should be explained that in laying the tile various methods were used in different sections of the field. On certain strips of land the tile were placed 36 to 40 inches below the surface, while on alternating strips they were laid 20 to 24 inches deep. Also, four different methods of covering were tried. In one section the tile were covered with about 4 inches of gravel before the ditch was filled in, in another about 4 inches of cinders were used, in the third section about 6 inches of straw, and in the fourth the tile were covered with the soil in the ordinary manner.

The data are not sufficiently extensive to warrant a comparison of results from these different ways of laying the tile, but that the drainage system as a whole was effective can be readily seen in the differences in crop yields. It seems probable that these precautions in covering the tile to prevent silting in may have been a large factor in the effectiveness of the tiling. The "gains for tile-drainage" are given in Table 7.

TABLE 7.—FAIRFIELD FIELD: AVERAGE ANNUAL GAINS PER ACRE FOR TILE-DRAINAGE
Bushels or (tons) per acre

Soil treatment	Corn	Wheat	Soybeans
RLP	5.5	.6	1.3
R	12.9	3.6	3.1
MLP	6.5	3.3	(.06)
M	6.9	4.6	(.17)

All the averages are consistent in showing more or less increase in yield from tiling. The corn, especially, appears to have been considerably advantaged by the better drainage, the increase in yield ranging under the various fertilizing treatments from 5½ bushels to nearly 13 bushels an acre, and if corn were the only crop to be considered, the tiling would have been a profitable undertaking. Under the better systems of soil treatment the beneficial effects of the tiling were

TABLE 8.—FAIRFIELD FIELD: SPECIAL POTASSIUM TEST (1907-1915)
Bushels or (tons) per acre

Soil treatment	1907 Corn	1908 Corn	1909 Corn	1910 Clover	1910 Corn	1911 Clover	1911 Corn	1912 Clover	1912 Corn	1913 Corn	1915 Corn	Average corn	Average clover
Land tile-drained													
R	30.9	28.4	45.1	....	33.1	....	29.2	....	24.1	9.8	19.2	27.5	....
R, Potassium sulfate	31.4	30.4	50.2	....	48.8	....	23.9	....	21.0	14.8	26.4	30.9	....
R, Kainit	35.4	26.8	50.1	....	50.2	....	24.9	....	21.8	9.8	29.2	31.0	....
M	27.1	38.6	35.5	....	34.4	....	31.2	....	25.7	5.9	22.7	27.6	....
M, Potassium sulfate	29.6	38.6	47.7	....	50.4	....	31.1	....	20.0	8.1	25.0	31.3	....
M, Kainit	34.9	36.6	42.9	....	46.6	....	29.2	....	21.0	7.4	32.2	31.4	....
RLrP	37.0	20.8	27.3	2.00	55.1	....	35.0	.27	38.6	1.6	39.5	31.9	1.14
RLrP, Potassium sulfate	38.7	19.5	36.0	2.29	59.2	....	35.4	.41	33.5	2.0	47.1	33.9	1.35
RLrP, Kainit	45.6	26.4	34.0	2.54	59.8	....	33.6	.45	46.1	3.1	45.5	36.8	1.50
MLrP	48.0	38.5	41.3	(3.62)	64.6	(.94)	35.4	(2.05)	57.0	2.6	47.0	41.8	(2.20)
MLrP, Potassium sulfate	50.3	37.2	39.0	(3.97)	67.5	(.95)	38.6	(2.55)	52.8	5.4	46.3	42.1	(2.49)
MLrP, Kainit	52.4	35.5	40.6	(4.59)	68.2	(1.15)	40.6	(2.10)	62.9	3.4	47.8	43.9	(2.61)
Land not tile-drained													
R	30.4	15.6	14.9	....	33.1	....	26.2	....	3.9	.7	22.0	18.4	....
R, Potassium sulfate	38.8	11.6	18.8	....	42.8	....	24.6	....	.6	2.1	34.8	21.8	....
R, Kainit	37.2	16.6	19.2	....	36.9	....	21.7	....	.4	2.5	33.6	21.0	....
M	40.4	30.8	19.4	....	52.6	....	36.6	....	6.7	3.7	35.3	28.2	....
M, Potassium sulfate	42.8	30.4	19.6	....	65.2	....	35.7	....	3.2	3.4	34.3	29.3	....
M, Kainit	44.9	29.6	17.1	....	66.2	....	37.5	....	2.3	3.9	39.9	30.2	....
RLrP	40.9	20.6	23.1	.89	46.0	....	33.7	.37	25.7	2.1	39.2	28.9	.63
RLrP, Potassium sulfate	49.9	26.1	37.6	1.98	48.3	....	31.7	.39	21.9	2.5	55.2	34.2	1.19
RLrP, Kainit	53.9	31.4	34.1	2.03	48.4	....	30.1	.43	27.8	2.4	52.8	35.1	1.23
MLrP	49.8	39.7	32.2	(3.50)	62.9	(.70)	31.5	(1.50)	24.0	2.0	43.2	35.7	(1.90)
MLrP, Potassium sulfate	52.3	39.5	33.8	(3.89)	65.3	(.94)	30.9	(1.90)	18.0	2.3	46.6	36.1	(2.24)
MLrP, Kainit	54.7	38.9	34.3	(3.93)	65.0	(1.06)	31.8	(2.00)	26.7	1.6	48.2	37.7	(2.33)

less pronounced. Considering the increased yields as a whole, one can see that the installation of such a tiling system, especially under present-day high costs, would be a doubtful investment.

The Potassium Experiments

In addition to the above-described soil treatments, potassium compounds were applied in two forms; namely, kainit and sulfate. Applications were made lengthwise of all series in such manner that a 4-rod strip in the middle received kainit at the annual acre-rate of 150 pounds, and a 2-rod strip on either side of the kainit received potassium sulfate at the annual acre-rate of 50 pounds. These treatments were continued from 1907 to 1915. The effect of the potassium treatments on the crop yields was measured only in the corn for the years 1907 to 1915 and in the clover for the years 1910, 1911, and 1912. The results are

TABLE 9.—FAIRFIELD FIELD: AVERAGE ANNUAL GAINS FOR POTASSIUM
Bushels or (tons) per acre

Basal soil treatment	Corn		Clover[1]	
	Sulfate	Kainit	Sulfate	Kainit
Land tile-drained				
Residues	3.4	3.5	....	....
Manure	3.7	3.8	....	....
Residues + LP	2.0	4.9	(.21)	(.36)
Manure + LP	.3	2.1	(.29)	(.41)
Land not tile-drained				
Residues	3.4	2.6	....	....
Manure	1.1	2.0	....	....
Residues + LP	5.3	6.2	(.56)	(.60)
Manure + LP	.4	2.0	(.34)	(.43)

[1]Clover yields were obtained only on land receiving limestone.

given in Table 8 and a summary in terms of increases in yield is found in Table 9.

The results of these tests are consistent in showing some gain for potassium in all comparisons, altho in some cases the amounts are scarcely significant. The greatest effects appear in the residues system where limestone and phosphate are included in the treatment. On the land not tile-drained, the gain in corn amounted to more than 5 bushels an acre, and in clover it was over one-half ton of hay. On the other hand, in the manure system the gain for potassium treatment is scarcely significant; but this effect is not surprising, for the manure itself supplies a considerable quantity of potassium.

As between these two carriers of potassium, sulfate and kainit, such differences as exist are, with one exception, in favor of kainit.

Summary of the Fairfield Soil Experiments

On the whole, the results on the Fairfield plots are typical of those obtained on other experiment fields and on many farms located on similar soil. They demonstrate the possibility of improving production thru the use of limestone and organic manures. The best yields were obtained where stable manure was employed, but seldom is there a farm where enough stable manure is available to use in the manner of these experiments, and so the growing of legumes, especially sweet clover, and the plowing down of crop residues are urged as a means of supplying the essential nitrogen and organic matter.

The results for potash seem to justify the use of potassium fertilizers, particularly for corn and especially in the absence of stable manure. These experiments do not answer the phosphorus question, but with the test mentioned on page 58 the farmer has a helpful guide in deciding on the purchase of phosphorus fertilizers.

It should perhaps be pointed out that these experiments are intended to determine the principles involved in dealing with this kind of soil rather than to demonstrate any special system of farm management. While the rotation used served the purpose of the experiments, it may be that crops other than those that were employed here could be grown to advantage. Where circumstances permit, it might be that the raising of livestock could well occupy a larger place than it does at present in economic utilization of this land.

NEWTON FIELD

A 30-acre experiment field has been maintained by the University at Newton in Jasper county since 1912. The soil type has been mapped as Gray Silt Loam On Tight Clay, tho the field is not altogether uniform, as is shown by variations in the crop yields. The land is almost level. A system of tile was installed, but owing to the impervious nature of the subsoil the tile did not materially improve the drainage until the scheme was devised of using the tiles as sewers to carry away the surplus water conducted to them thru a system of ditches and catch basins.

The field is laid off into twelve series of plots and these series now make up three separate combinations, or plot systems. Only one of these combinations, consisting of Series 100 to 400, will be considered here. On these four series a rotation of corn, mixed hay, wheat, and oats is at present being practiced. Soybeans were formerly grown instead of mixed hay. Cowpeas have been seeded in the corn and sweet clover in the wheat as catch crops to help supply organic matter and nitrogen on the residues plots. In 1920 the use of the cowpea crop was discontinued, as was also the return of wheat straw in 1922.

The limestone used on these series has been of the dolomitic form ground sufficiently fine to pass a 10-mesh sieve. The usual large initial amount of limestone was not applied here. Up to 1922 the different series had received 5 to 6 tons an acre, when the regular applications were suspended until further need for lime should become apparent.

Table 10 gives a summary of the crop yields obtained, including the years that the various complete soil treatments have been in effect.

TABLE 10.—NEWTON FIELD: SERIES 100, 200, 300, AND 400, SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *22 crops*	Soybeans *17 crops*	Wheat *18 crops*	Oats *3 crops*	Mixed hay *3 crops*	Stubble clover *2 crops*
1	0	9.5	(.61)	.8	9.7	(.74)	(0)
2	M	15.1	(.83)	2.0	19.6	(.85)	(0)
3	ML	26.2	(1.17)	11.3	23.2	(1.77)	(.59)
4	MLP	25.8	(1.25)	15.9	23.9	(2.29)	(.88)
5	0	9.8	(.58)	1.6	12.7	(.68)	(0)
6	R	9.8	(.55)	1.7	13.1	(.75)	(0)
7	RL	16.4	(.90)	8.6	21.9	(1.46)	(.34)
8	RLP	16.8	(.99)	14.2	23.4	(1.73)	(.52)
9	RLPK	22.0	(1.10)	18.6	19.4	(2.28)	(.83)
10	0	6.9	(.54)	.9	10.5	(.88)	(0)

The results of these experiments are characteristic of those of other fields located on this soil type. They demonstrate once more the absolute necessity of liming as the foundation for soil improvement. Without lime, legumes fail completely and the use of manure alone is practically ineffective. Phosphorus in combination with lime and organic manure has, as usual, materially benefited the wheat but, in the manner used in these experiments, the rock phosphate has not paid for itself. Increases in the yields of all crops excepting oats have followed the use of a potassium fertilizer; the money value of this increase is now sufficient to return some profit on the investment.

Altho the above results show very large percentage increases for proper soil treatment, particularly for liming, yet with the best yields obtained the total production is not very high. The rather simple cropping system serves the purpose of bringing out the possibilities of improving this soil; more profitable systems of farming, in which other products are included in the farm output, can doubtless be developed by thoughtful planning.

FIG. 7.—WITHOUT LIMESTONE SWEET CLOVER REFUSES TO GROW
A photographic record of adjacent plots on the Newton field. At the right where no clover is seen, no limestone has been applied.

EWING FIELD

As representing the soil type Gray Silt Loam On Orange-Mottled Tight Clay, experimental results from a portion of the Ewing field are presented.

The Ewing Field is located in Franklin county about a mile northeast of Ewing. It was established in 1910. Altho four distinguishable soil types have been identified on this field, the 100 and 200 series of plots lie wholly on Gray Silt Loam On Orange-Mottled Tight Clay. This land is nearly level, the drainage is poor, and the soil is strongly acid. These two series, together with Series 300 and 400, constitute a plot system farmed under a crop rotation of wheat, corn, oats, and clover; but because Series 300 and 400 lie mainly on another soil type, results from these plots will not enter into the present consideration.

The handling of the crops and the soil treatments have been in the main according to the somewhat standard plan described above. Until 1920 cowpeas were seeded in the corn as a catch crop on the residues plots. In 1921 sweet clover was substituted as the regular legume in the rotation in addition to its seeding in the wheat for use as a green-manure crop. Seed was harvested from all the regular sweet-clover plots and the straw returned to the residues plots. In 1922 the limestone applications were discontinued after they had reached a total quantity of 8½ to 10 tons an acre on the different series. No more limestone will be applied until the need for it appears. The return of the wheat straw as a residue was also discontinued at that time. In 1923 the rock phosphate was evened up on all phosphorus plots to 8,500 pounds an acre in total applications and no more will be applied for an indefinite period.

A summary of the results is presented in Table 11, showing the average annual crop yields obtained for the years the plots have been under their complete treatments. The extremely poor yields on the untreated land are characteristic of this soil. About 2.5 bushels of wheat an acre has been the average production on the check plots.

The use of manure alone increases the crop yields somewhat, but not sufficiently to put this kind of farming on a profitable basis. Residues alone are practically without effect.

TABLE 11.—EWING FIELD: SERIES 100 AND 200, SUMMARY OF CROP YIELDS
Average Annual Yields 1911-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *8 crops*	Corn *10 crops*	Oats *10 crops*	Clover *1 crop*	Sweet clover *2 crops*	Mixed hay *2 crops*	Soy-beans *4 crops*
1	0	2.3	12.9	8.4	(.20)	0	(.47)	(.46)
2	M	5.2	27.1	14.2	(.24)	0	(.59)	(.54)
3	ML	18.1	49.6	30.6	(.40)	2.23	(1.89)	(1.08)
4	MLP	22.9	50.1	32.8	(.81)	2.25	(2.31)	(1.23)
5	0	2.2	12.2	9.0	0	0	(.60)	(.34)
6	R	1.8	12.3	9.2	0	0	(.69)	(.36)
7	RL	17.5	29.8	27.0	.50	2.46	(1.67)	(.86)
8	RLP	20.2	27.6	27.9	1.08	2.07	(1.64)	(.93)
9	RLPK	28.2	47.6	35.4	.75	2.09	(2.19)	(1.11)
10	0	3.3	16.7	9.9	0	0	(.68)	(.56)

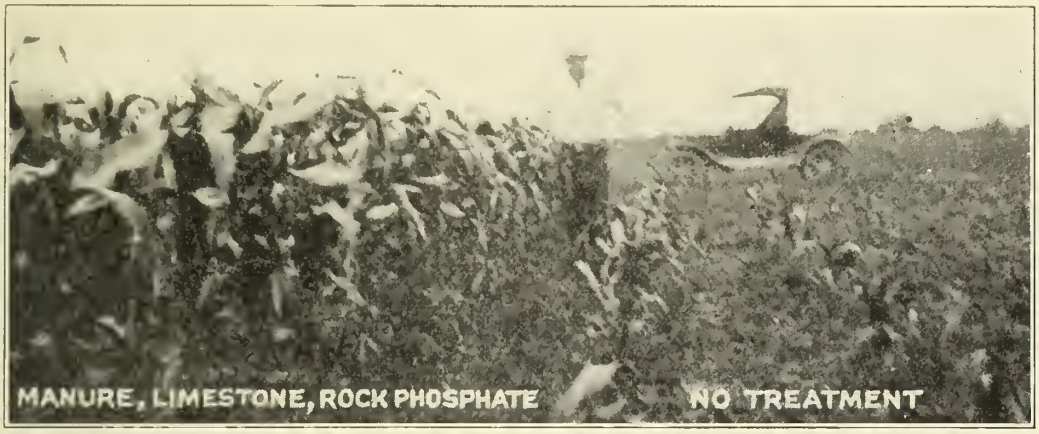


FIG. 8.—CORN GROWING ON NEIGHBORING PLOTS ON THE EWING FIELD IN 1924

At the right is a check plot which produced, as an average of eight years, only 15 bushels of corn an acre; while at the left the plot treated with manure, limestone, and rock phosphate produced 49 bushels an acre as an average for this same period.

Limestone produces a very decided increase in yields used either with manure or with residues, the large increase with the latter being due mainly to the successful growth of legumes following the application of limestone. A financial study of these treatments covering the last rotation period reveals the fact that manure and limestone is now the most effective combination of the various treatment systems under test. At the prices assumed in the estimate, manure and limestone are returning $16.16 an acre a year in value of crop increases after deducting the cost of the treatment.

The results for rock phosphate are rather peculiar in that they are more favorable in the manure system than in the residues system. This unusual behavior may perhaps be explained by the fact that potassium has become a limiting element on this field and that the manure furnishes a certain amount of this substance.

Potassium fertilizer as used in these experiments has had a very beneficial effect on all the grain crops. In fact, within the last few years, in the corn crop under the residues system, the need for potassium has become decidedly acute. Thus the average yield of corn for the last five crops under the lime, residues, and phosphorus treatment was 17.9 bushels an acre, while on the adjoining plot with potassium added to the treatment the yield was 48.1 bushels an acre. One year the yield without potassium was 5 bushels an acre while with potassium it was 52.3 bushels.

As mentioned above, manure and limestone is proving the most remunerative treatment on the Ewing field. But unfortunately manure is not abundant. The next best paying system is the combination residues, limestone, phosphate, and potash, which returned a net value of $16.31 an acre a year in crop increases produced.

The recommendation, therefore, for improving land of this type is to apply limestone, use all available farm manure, plow under sweet clover, and return unused crop residues to the soil. Then to this basal program add potassium and phosphorus as the need for these materials develops.

SPARTA FIELD

As representative of experimental results on the soil type Light Gray Silt Loam On Tight Clay, data from certain plots on the Sparta experiment field are introduced here.

The Sparta field was established in Randolph county immediately north of the town of Sparta in 1916. The four series of plots designated as the 100, 200, 300, and 400 series, with the exception of parts of two plots, are all on the soil type mapped as Light Gray Silt Loam On Tight Clay. They are under a crop rotation of corn, soybeans, wheat, and clover (chiefly sweet clover). Until 1921 it was the practice to seed cowpeas as a cover crop in the corn on the residues plots. The soil treatments are as indicated in the accompanying table, and they have been applied in the manner previously described, with the exception that the initial application of limestone was 5 tons an acre. In 1922 the application of this material was discontinued until its further need should become apparent. Table 12 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years that the complete soil treatments have been in effect.

The low yields on the untreated plots testify to the natural poverty of this soil, altho this particular piece of land, on account of its favorable location with respect to drainage, is rather more productive than the general run of the type that it represents.

Neither manure nor residues, used alone, has much effect toward crop improvement. A sharp increase, however, follows the application of limestone used with either manure or residues. Without limestone, clover refuses to grow; with limestone, fair crops of clover have been obtained. Rock phosphate in addition to limestone has produced no significant effect, used either with manure or with residues.

Potassium has been of considerable benefit to the corn and clover but not so much to the other crops. This suggests a possibility of a more profitable use of kainit (which furnishes the potassium) by cutting down the quantity used and applying directly for the benefit of the corn and clover crops, thereby effecting a considerable saving in the cost of material.

TABLE 12.—SPARTA FIELD: SERIES 100, 200, 300, AND 400, SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *13 crops*	Soybeans *12 crops*	Wheat *9 crops*	Clover *1 crop*	Sweet clover *8 crops*
1	0	14.9	5.9	4.6	(0)	0
2	M	19.4	7.5	6.8	(0)	0
3	ML	31.0	14.5	15.9	(1.66)	1.87
4	MLP	32.2	14.8	16.6	(1.73)	1.50
5	0	12.5	4.6	4.8	(0)	0
6	R	16.4	5.5	4.9	(0)	0
7	RL	26.1	12.8	14.9	(1.30)	1.40
8	RLP	25.5	13.3	15.7	(1.47)	1.48
9	RLPK	32.6	14.2	16.5	(2.01)	2.27
10	0	11.2	4.8	3.9	(0)	0

RALEIGH FIELD

As representing the soil type Yellow-Gray Silt Loam On Tight Clay the results from a portion of the University experiment field located at Raleigh in Saline county are presented here. Series 200 and 300, which lie on this soil type, form a part of a plot system kept under a crop rotation of wheat, corn, oats, and clover. When clover fails soybeans are substituted.

The general management and soil treatments are as described above, page 30. In 1922 the practice of returning the wheat straw in the residues system was discontinued. In the same year the regular applications of limestone were suspended until such time as lime appears to be needed again. In 1923 the rock phosphate was evened up on all phosphate plots to a total application of 4¼ tons an acre and the applications were discontinued for an indefinite period. The results in terms of average annual yields of the respective kinds of crops are summarized in Table 13.

TABLE 13.—RALEIGH FIELD: SERIES 200 AND 300, SUMMARY OF CROP YIELDS
Average Annual Yields 1911-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *5 crops*	Corn *10 crops*	Oats *10 crops*	Clover *2 crops*	Soybeans *6 crops*
1	0	2.2	11.4	10.2	(.13)	4.8
2	M	4.5	23.4	15.6	(.06)	8.3
3	ML	12.8	40.0	26.3	(.64)	12.9
4	MLP	14.6	41.9	25.9	(.68)	14.2
5	0	2.6	12.1	10.6	(0)	4.6
6	R	3.9	16.4	13.6	(0)	5.1
7	RL	10.0	34.8	23.9	(.18)	10.0
8	RLP	11.5	40.0	26.4	(.32)	11.2
9	RLPK	14.5	47.3	27.3	(.60)	12.1
10	0	4.5	19.7	14.0	(.06)	8.3

A study of these data brings out the following comments concerning the effects of the various treatments on the Raleigh field:

1. The untreated plots are conspicuous in their low yields.
2. All the different kinds of grain crops show some response to the application of stable manure, altho the beneficial effect varies greatly.
3. Crop residues used alone have been of very little effect.
4. Limestone in combination either with manure or with crop residues stands out in its effect as the most prominent agency in soil improvement.
5. The application of rock phosphate has produced little effect, so that on the whole the use of this material in the manner of these experiments has been attended by a financial loss.
6. Potassium in the form of kainit has increased the yield of all crops, particularly the corn, wheat, and clover. At current prices the value of the increase is just about offset by the cost of the kainit applied.

Regarding the cropping system employed on this field, it may be said that altho it serves for experimental purposes in determining the needs of the soil, for farming practice it doubtless could be improved either by substituting a more

profitable crop for the oats, or by rearranging the crop sequence and omitting the oats. Doubtless other cropping plans could be devised to advantage.

FIG. 9.—CORN ON THE RALEIGH FIELD

At the right no treatment has been applied; at the left, manure, limestone, and phosphate have been applied, the major effect being produced by the limestone and manure.

APPENDIX

PRINCIPLES OF SOIL MANAGEMENT

Clear thinking on the complex problems of soil management must start with a realization that there are many different kinds of soils, each differing from the others in soil characters. The fertilizer, management, and cropping requirements of each kind of soil are not yet fully worked out, altho knowledge regarding the agricultural significance of the various soil types recognized in the soil survey is rapidly accumulating.

Soils are dynamic, exceedingly complex, natural bodies made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, soils cannot be considered as reservoirs into which given quantities of an element or elements of plant food can be poured with the assurance that they can be expected to respond uniformly to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance to favor the growth of higher plants and of beneficial microorganisms.

It is obvious that in order to fulfill these conditions no single system of soil treatment can be laid down for all situations. The long-time records from numerous soil experiment fields scattered over Illinois demonstrate strikingly that different soils require different management practices. Some soils are naturally so productive that no fertilizer treatment yet tried has succeeded, on a paying basis, in raising the crop yields over their natural capacity. On the other hand, there are other soils so poor that altho under proper treatment the yield can be increased many fold, the plane of production under the best management known is still so low that it is questionable whether it pays to farm the land at all. Between these two extremes all grades of productivity are found. A further significant fact brought out in a study of these experiment fields is that a given piece of land seldom responds to soil treatments in the same manner thruout its history. The most efficient treatment during one rotation period does not necessarily remain the most efficient in another period.

Thus it appears that soil management is a complex matter even when considered from only one side of the problem, namely, that of producing crops. In addition to these complexities connected with production, however, are those having to do with the everchanging economic conditions by which market prices are affected. Whether a certain yield produced by a given soil treatment will be profitable depends directly upon the price of produce as well as upon the cost of the treatment, and every farmer knows only too well something of the violent fluctuations in market prices that have taken place in recent years. Furthermore, costs of fertilizing materials change from time to time, and these changes do not necessarily run parallel with the fluctuations in value of farm products.

With these facts in mind it is not difficult to understand that, from the standpoint of financial profits, a soil-management practice perfectly recommendable this year may become wholly unprofitable in another year and, vice versa, a practice that is unprofitable under present conditions may become highly profitable at another time.

The above remarks suggest something of the difficulty of prescribing definite recommendations for specific soil treatments and of the futility of making blanket recommendations to cover the requirements of all soils and all crops at all times. In mentioning these difficulties there is no intention to discourage efforts at planning programs of soil improvement; the purpose, rather, is to set forth some of the uncertainties involved and, in particular, to warn against hasty conclusions based upon scanty experience or superficial observation.

In spite of the many complexities involved in the problem of soil improvement, there are certain broad, underlying principles that are basic and that must be taken into consideration in laying out any improvement program. Underlying the permanent and profitable productivity of the soil is the maintenance of good physical condition, favorable biological activity, a suitable soil reaction, and an adequate supply of available plant-food elements during the growing season. The chief practices which accomplish these ends are—

1. Adequate drainage
2. Protection from erosion
3. Application of limestone where necessary
4. A good cropping system, including suitable legumes for soil improvement
5. Provision for active organic matter by returning regularly animal and plant manures
6. Purchase of mineral plant-food elements to supply deficiencies

PROVIDING ADEQUATE DRAINAGE

Adequate drainage is recognized as essential for the consistent production of satisfactory crops. Crops vary, however, in their ability to endure poor drainage. Alsike clover, for example, is better adapted to wet land than is red clover. Some bottom lands produce excellent summer crops but cannot be used for winter crops because of flooding. Altho such lands may not be well drained, it is often possible to raise good crops of corn on them year after year, because, as a result of frequent overflow, they receive periodically a fresh deposit of soil material. Such a practice on poorly drained upland would not be feasible. Upland soils, with few if any exceptions, require a well-planned cropping system if they are to be utilized most efficiently, and such a system is difficult to follow unless adequate drainage is provided.

Soils differ in permeability and consequently in their response to the installation of tile. There are soils in the southern and southwestern parts of Illinois, occupying a large total area, which cannot be drained successfully with tile because they have an impervious, clay-pan subsoil. In the east-central part of the state there is a soil occupying a considerable area which does not underdrain well because of an impervious glacial drift which comes to within 30 inches or less of the surface.

The soils of Illinois may well be artificially underdrained with the exception of those noted above. The soils which cannot be underdrained must be drained by means of open ditches and furrows or by means of a combination of open ditches, furrows, and tile provided with manholes thru which the water may enter the tile. In some soils the efficiency of the tile may be greatly increased by starting to fill the tile ditches with top-soil instead of with the more impervious material taken from the bottom of the ditches.

There are some soils in Illinois that cannot be satisfactorily drained either by tile or by open ditches. There should be no attempt to utilize such soils for general farming purposes.

PROTECTING SOIL FROM EROSION

The erosion problem is a serious one in Illinois. We are accustomed to think of erosion as being harmful only on rough and strongly rolling land. This seems, however, to be far from the truth.

The land surface subject to erosion in Illinois might be considered to include three groups of soils based on steepness of slope. The first group might be characterized as being subject to destructive erosion. Land of this character is located, for the most part, adjacent to streams and comprizes a total area in the state of some 7,000 square miles. Land subject to destructive erosion, is for the most part unsuited to general farming. If used for this purpose, erosion is so difficult to control that the returns do not justify the expense involved. Some of the land of this character may be used for orcharding and some of it may be used for permanent pasture but a large proportion of it is suitable only for timber.

A second group of erodible soils may be considered to include land suitable, under proper protection, for permanent pasture and orcharding but unsuited to general farming because of the steepness of the slopes resulting in destructive erosion if tilled. Land of this general character includes some 8,000 square miles. Terracing is recommendable on land of this character as affording a relatively inexpensive and an effective means of reducing erosion. There will be times however, when erosion will be severe on land of this general character even on fields where the best known methods of control are being used.

Generally speaking the two groups mentioned above comprize land of relatively low agricultural value, as this term is commonly understood. If, however, certain of these soils are used for purposes for which they are adapted, they may be of considerable or, in some cases, of high value.

A third group comprizes the gently rolling to rolling land thruout the northern two-thirds of the state. Some 25,000 square miles may be included in this group. This land has a high value for general farming but is subject to harmful erosion and much of it is being seriously damaged thru the removal of surface soil by running water. The erosion problem presented by this third group is probably of more serious concern than that presented by either of the other two because of the high value of the land involved. Erosion can be controlled on a large proportion of this land by means of a good cropping system. Provision should be made for a protecting cover of vegetation particularly in the fall and spring. Cornstalks rolled down at a right angle to the slope are very effective in

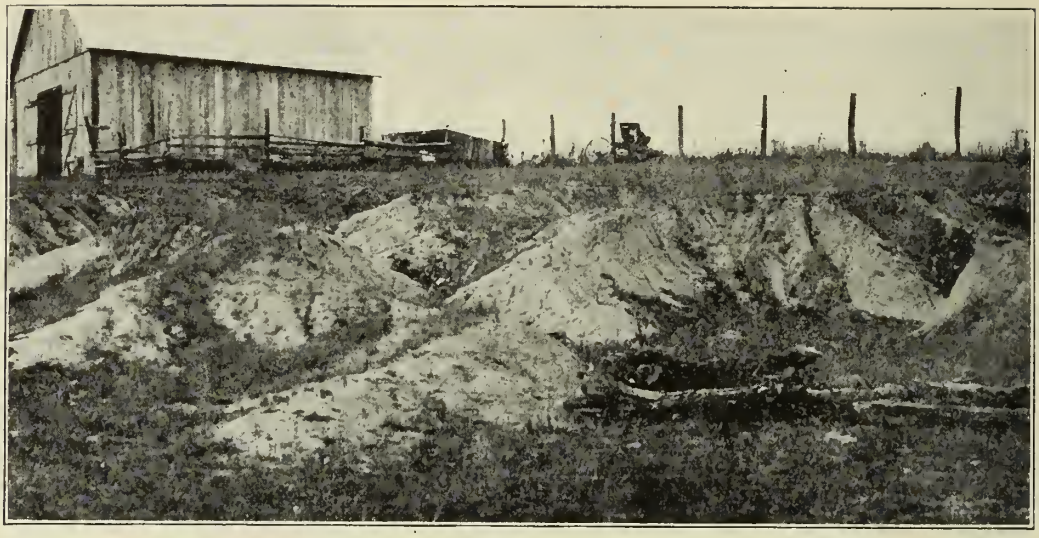


FIG. 10.—PROPER SOIL TREATMENT AND CROPPING WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 11.

reducing erosion on this gently sloping land. Long shallow draws may often be kept in permanent sod to great advantage. Broad base terraces may be effectively used where the slope is a little too steep for effective control to be secured with a good cropping system only. It is surprising however how effective a good cropping system is in decreasing washing. Experimental results indicate that on relatively gentle slopes of about 4 percent the surface seven inches of soil may be washed off in about twenty-five years where a poor cropping systm is used, and that the use of a good cropping system alone will extend the time for the removal of the same amount of soil to some 350 years.

The method or combination of methods suitable for the control of erosion on any given area depends on many factors; that is to say, no generally applicable,

FIG. 11.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 10.

detailed directions for controlling erosion can be given because such important factors as steepness of slope, length of slope, and permeability of the soil must be taken into consideration.

A detailed discussion of methods of controlling erosion will be found in Bulletin 207, "Washing of Soils and Methods of Prevention," and Circular 290, "Saving Soil by Use of Mangum Terraces," published by this Station.

APPLYING LIMESTONE TO CORRECT ACIDITY

The maintenance of a favorable soil reaction has been mentioned as one of the essentials in a rational system of soil management, and in contemplating a soil-improvement program one of the first steps for consideration is the application of limestone.

In considering the use of limestone it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, a plant-food element for which certain crops have a high requirement. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial bacteria. It plays an essential role in the chemical transformation of nitrogen. It helps to check the growth of certain fungous diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Most important of all its properties is its power to neutralize soil acidity, thus making possible thru the growing of legumes the reclamation of millions of unproductive acres as well as the improvement of land of moderate or even high productive capacity.

Soils vary tremendously with respect to acidity, and the question arises as to how the farmer is to know whether his land needs limestone. Much information on this subject, as it pertains to Illinois land, is to be found in connection with the soil survey. Some soil types are uniformly acid, and therefore in their description attention is called to the necessity of applying limestone; other types being alkaline thruout, do not need lime, and in the discussion this fact is recorded. There are, however, extensive soil types in which the lime requirement is not uniform. It may vary from field to field on the same farm. It may even change on a given field with the passing of time, especially under heavy cropping. Obviously in such cases a definite recommendation in regard to liming cannot be given, and under these circumstances the farmer is advised to resort to a test which he himself can learn to make.

Any citizen of the state may obtain from the county farm adviser or from the Experiment Station instructions for making a systematic limestone map of his fields, showing not only the areas that need liming but also approximately the amount of limestone to apply. Such a test made on soils where the lime requirement is decidedly variable is saving many hundreds of dollars in expenditures for limestone where limestone is not needed, as well as preventing the waste of clover seed on soils too acid to grow clover. For a description of this test see Circular 346 of this Station, "Test Your Soil for Acidity."

A good indication as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover. This crop does not thrive on acid soils and its thrifty growth therefore indicates that the soil is not acid, at least in a harmful degree. Some legumes, for example red clover, will grow fairly well on soil of moderate acidity provided conditions are otherwise favorable. Too much reliance therefore should not be placed on the behavior of

FIG. 12.—SWEET CLOVER AS AN INDICATOR OF THE NEED FOR LIMESTONE
Left, no limestone; right, limestone. Sweet clover is one of the most sensitive crops to soil acidity. This crop will not grow on acid soils until limestone has been applied.

legumes as an indicator of the need of liming, for it frequently happens that fair stands are mistaken for good stands and even good yields can often be greatly increased by the use of limestone. Therefore it is well to be definitely informed regarding the condition of the soil with respect to acidity, using, where necessary, a reliable test such as that mentioned above.

MAINTAINING A WELL-PLANNED CROP ROTATION

In any program of permanent soil improvement one should adopt at the outset a good system of crop rotation, including a liberal use of legumes. It is impossible to prescribe the best rotation for every individual case because what will prove to be the most advantageous system to follow depends upon a number of different factors. Of primary importance among these factors is the location of the farm with respect to soil, to climate, and to market. The particular rotation to be followed will be determined further by the type of farming—whether grain, livestock, orcharding, or other kind of enterprise. Finally, not the least important to be considered are the personal interests and inclinations of the farmer himself.

Following are a few suggested rotations, applicable mainly to the corn belt, which are intended to serve merely as patterns or outlines, to be modified according to special circumstances. In these suggested rotation programs the more common crops are mentioned merely as types, for which other crops of similar nature may be substituted as desired. In the following lists, for example, oats may be replaced by barley or spring wheat, and likewise winter rye might take the place of winter wheat. Or it may be advisable in some cases to divide the acreage of small grain and raise different kinds; for example, plant a part of the land to oats and a part to barley. The word "clover" in the following lists of rotations is used in a general sense to designate red, alsike, or sweet clover, or even a clover-grass mixture to serve either as pasture or meadow. In the event

of clover failure soybeans may be substituted. The value of sweet clover, especially as a green manure, for building up depleted soils is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized. In the following lists the word "clover" in parentheses signifies that clover is seeded in the grain crop.

Numberless different cropping systems might be enumerated, ranging thru various long-term and short-term rotations, but it will suffice for the present purpose to mention only a few systems as suggestive of types of rotations.

Six-Year Rotations

Among the longer type of rotations the following six-year systems are suggested as being good practical rotations adaptable under many circumstances. Two such programs are presented, one in which corn predominates and the other in which wheat is the major crop. Following are the crop sequences:

System A	*System B*
Corn	Corn
Corn	Oats
Oats (clover)	Wheat (clover)
Clover	Clover
Wheat (clover)	Wheat (clover)
Clover	Clover

In grain farming most of the crop residues are returned to the soil and the clover may be left on the land or returned after threshing out the seed. In livestock farming the clover may be mixed with alfalfa or with timothy, the crop being used for pasture or for meadow as desired. Soybeans, a crop that is rapidly coming into favor, can be introduced into System A by replacing either the first or the second corn crop or the last clover crop. In System B perhaps the best place for soybeans would be following the second wheat crop, altho it is possible to grow them in place of the oats.

An objection sometimes arises to wheat following clover on account of the wheat lodging. This lodging is not so likely to happen when the clover is cut as hay and removed from the land.

Five-Year Rotations

A five-year rotation system offers one of the most convenient cropping plans that can be devised for general farming. It is flexible, it provides diversification, and it can be made to give large place to legumes.

Here, three different basal systems are presented. Systems C and E are designed for corn as the major crop while System D is intended to give large place to wheat growing.

System C	*System D*	*System E*
Corn	Corn	Corn
Corn	Oats	Corn
Oats (clover)	Wheat (clover)	Soybeans
Clover	Clover	Oats (hubam)
Wheat (clover)	Wheat (clover)	Wheat (sweet clover)

It is of interest to observe in System C that if soybeans were to replace second-year corn, and the clover catch crop were allowed to grow awhile in the

spring before corn planting, then a legume crop would appear on every acre every year. The same provision could be effected in System D by replacing the oats with soybeans.

A growing problem on many farms where little livestock is fed is the economical disposal of the clover crop. A farmer can ill afford to give up a considerable portion of his land every year to clover production when he can neither feed nor sell the crop. In order to solve this problem the rotation mentioned as System E is proposed. The hubam is an annual sweet clover which seeded in the oats makes a heavy growth to plow down in preparation for the wheat and this, together with the biennial sweet clover grown in the wheat the following year, should furnish plenty of leguminous growth to maintain the rotation, leaving all the land free every year for a cash crop.

Four-Year Rotations

The four-year rotation represents a rather common cropping system. Among the several possibilities the following are suggested as practical programs for a four-year rotation:

System F	*System G*	*System H*
Corn	Corn	Corn
Corn	Oats	Corn
Oats (clover)	Wheat (clover)	Oats (hubam)
Clover	Clover	Wheat (sweet clover)

System F which calls for half the land to be in corn, requires a productive soil. However, half the land is under legumes and this is also true of System G. Soybeans might take the place of one of the corn crops in Systems F and H. In System G they might take the place of the oats provided the bean crop is removed early in order to make way for the fall seeding of the wheat.

System H is proposed in order to accomplish the same purpose in a four-year rotation as System E in the five-year program, namely, to provide for a salable crop on all fields every year.

Three-Year Rotations

One of the most common rotations practiced in the corn belt is the three-year crop succession of corn, oats, and clover (System I). From the standpoint of soil maintenance this is a good rotation. Legumes appear on the land two years out of three. It is also advantageous from the standpoint of labor economy, for plowing is required only once in three years. Its main disadvantage perhaps lies in the restricted crop diversification.

System I	*System J*
Corn	Wheat (clover)
Oats (clover)	Corn
Clover	Soybeans

An opportunity to introduce wheat into a three-year cropping plan is offered in System J. It is of interest to note that by seeding a catch crop of sweet clover in the wheat, to be plowed under the following spring just before corn planting, the land is under legumes some portion of the season every year. It will be necessary to harvest the soybeans early either by using an early variety

or by cutting for hay in order to prepare the land for winter wheat. In some regions it may be desirable to substitute cowpeas for the soybeans.

Two-Year Rotation

The well-known practice of alternating corn and oats has long been pointed out as an example of a bad rotation under which thousands of corn-belt farms are headed toward ruination. However, with the advent of sweet clover, that great soil restorer, a corn-oats rotation becomes a practical possibility.

System K

Corn
Oats (sweet clover)

In this system sweet clover is sown in the oats, pastured in the fall and the following spring if desired, and then plowed down in preparation for corn. From the standpoint of soil upkeep, this cropping plan, which may fit well in certain situations, is offered as an interesting possibility, altho from the general farm-management point of view it may lack some of the advantages of the longer rotations described above.

Altho oats are mentioned as the spring grain crop, as a matter of fact, by dividing the land devoted to small grain and introducing barley, these two crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

Alfalfa and Pasture in Rotation

Alfalfa is a highly desirable crop to grow, especially in livestock farming. Its possible use as a biennial legume in the rotation has already been pointed out. It is often desirable, however, to include alfalfa as a perennial stand in the cropping system. This can be done by providing one extra field. The alfalfa occupies a field during a complete rotation period of the other crops plus one year extra. The alfalfa is then shifted to another field while the other crops rotate, and so on around the entire field system.

It may be observed that this same plan for alfalfa in rotation will provide for continuous pasture of any kind, either of perennial grass—redtop, for example, in southern Illinois—or of grass and clover mixture.

SUPPLYING RIGHT KINDS AND AMOUNTS OF ORGANIC MATTER

Organic matter acts beneficially chiefly in two ways: it helps to maintain favorable physical conditions in the soil; and it supplies food material for the microscopic organisms which inhabit the soil and which in turn, thru their life processes, effect many of the necessary chemical transformations that render plant food available for the growing crops.

The main sources of supply for organic matter are stable manure, crop residues, and green manures.

A recent study of the results from the soil experiment fields located in many different parts of Illinois reveals the fact that the system of treatment that has most frequently returned the greatest profit is manure with limestone. Of the eight systems compared, this proved to be the winning treatment on more than

half the fields. This fact indicates the very great value of stable manure and suggests the importance of its careful conservation and use on every farm where this material is available. On most farms, however, there is not sufficient animal manure produced to cover the land, and thus it becomes necessary to resort to some other supply of organic matter. The alternative here lies in the so-called "crop-residues" system, in which unused materials such as stalks, straw, and chaff are returned to the land and plowed under along with leguminous green-manure crops.

In connection with the application of organic matter, an important distinction between kinds of organic matter with respect to chemical make-up has come to be recognized within the last few years. It is commonly observed that an excessive application of straw or similar material is likely to produce a depression in crop growth which may result in lowering the yield. In addition to the unfavorable physical effect of plowing down a mass of decay-resistant material, particularly if dry weather ensues, a deterimental chemical effect may also follow. The large quantity of cellulose contained in straw stimulates the activities of a certain set of microscopic organisms. These may become so active as actually to compete with the growing plants for nitrate and so under certain circumstances to cause nitrogen hunger. Good judgment must therefore be exercised in applying strawy material. Heavy applications should ordinarily be avoided unless they can be plowed under with a good growth of legumes or else applied at such a time as not to interfere with a crop having a large nitrate requirement.

MINERAL PLANT-FOOD REQUIREMENTS AND SUPPLY

Ten chemical elements have long been accepted as being essential for the growth of the higher plants. These are carbon, hydrogen, oxygen, nitrogen,

TABLE 14.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

phosphorus, sulfur, potassium, calcium, magnesium, and iron. To this list certain other elements have been added from time to time as being either necessary in the physiological processes or else present merely on account of absorption from the soil solution.

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured indirectly from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient.

Table 14 shows the average content of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. It has been found, for example, that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds an acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil. In presenting these figures it is not intended

TABLE 15.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Superphosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 10. [2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

FIG. 13.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

to imply that plants are restricted in their feeding to the surface stratum, nor that the total quantities of the various plant-food elements give a reliable indication of the immediate fertilizer requirements of a soil except in extreme cases. Such extreme cases, however, are relatively rare and there are the great middle classes in which chemical composition varies so little as to furnish no clue whatever to the probable effect of a particular fertilizer treatment. Much depends upon the ability of the crops grown to utilize plant-food material, and much depends upon the solubility of the plant-food substances themselves. When an element becomes so reduced, either in total quantity or in available form, as to become a limiting factor of production, then we must look for some outside source of supply. Table 15 shows the approximate quantities of some of the more important plant-food elements contained in materials most commonly used as fertilizers.

Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost, when purchased on the open market, is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen.

Fig. 14.—Legumes Can Obtain Their Nitrogen from the Air

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

Leguminous plants such as the clovers are able, with the aid of certain bacteria, to draw upon this supply of air nitrogen, utilizing it in their food requirements. In so doing, these leguminous plants if returned to the land add to the soil a part of the nitrogen which has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow. By taking advantage of this fact and introducing periodically into the rotation system a crop of legumes, the farmer may draw upon this cheapest source of nitrogen for soil improvement. Therefore, in general farming, that is, in the production of such crops as corn, oats, wheat, and hay, legumes should furnish the main stock of nitrogen, this stock to be supplemented, of course, by all available manure and by other farm waste materials containing nitrogen.

In addition to these home sources of nitrogen supply, there are various commercial products containing nitrogen offered on the market. These materials formerly consisted largely of sodium nitrate, a mineral imported from South America; ammonium sulfate, produced in the manufacture of coal gas and coke; and certain waste and by-product materials mainly of organic composition. Within very recent time, however, tremendous developments in the synthetic production of nitrogen compounds from air nitrogen have taken place. Among these new fertilizer materials may be mentioned cyanamid, calcium nitrate, sodium nitrate, ammonium nitrate, and urea.

These developments in the artificial fixation of nitrogen will doubtless have a far-reaching effect in reducing the cost of commercial nitrogenous fertilizers. What the limits may be in this direction one dare not predict. Whether these manufactured nitrogen compounds will become so cheap some day as actually to compete with legume nitrogen is problematical, especially when the other advantages offered by legumes are considered. However, the day has not yet arrived when we can afford to dispense with legumes as a green manuring crop in the production of grain and hay.

Accepting, then, this principle that legumes and farm wastes must constitute the main source of nitrogen supply, the question arises—can these home-grown materials be supplemented to advantage by the use of commercial carriers of nitrogen?

The impossibility of making blanket recommendations has already been pointed out. The question finally resolves itself into a matter of expense and profit for each individual case. Sodium nitrate is purchased on the market at present at about $65 a ton. If a farmer applies 100 pounds an acre, he provides about two-fifths of an ounce to a hill of corn. A ton would cover 20 acres and the cost would be about $3.25 an acre. Under present prices an increase of about four to five bushels or corn or wheat would be required in order to cover the cost before any profit could be realized.

Under what circumstances might such increases in yield be reasonably expected? It is possible that in many cases where manure or legumes have not been used, such an application of nitrogen would return a profit, but such usage should be regarded as a temporary expedient rather than a permanent practice in soil management. Under adverse weather conditions, when soil nitrates are formed too slowly or are washed away by excessive rain, an application of nitrogen fertilizer may prove highly beneficial to wheat and corn.

A peculiar hazard accompanies the application of nitrogen that does not obtain in applying phosphate or potash. Nitrates are readily washed away, and if circumstances are such that the first crop fails to utilize the nitrogen, little or no residual effect on the following crops can be expected. For this reason special caution should be used against applying excessive amounts of nitrogen. Usually it is well to divide the application of a quickly soluble nitrogen fertilizer such as sodium nitrate, using a portion at planting time and distributing the remainder at a later date. Nitrogenous fertilizers are often made up of a mixture of materials whose nitrogen becomes soluble with varying degrees of rapidity, thus automatically distributing the action of the nitrogen over a period of time.

Phosphorus Problem

Different soil types display great variation in phosphorus content and, on the other hand, soils of like total-phosphorus content exhibit great variation in response to phosphate fertilization. The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of farm manure and phosphatic fertilizers and perhaps the use of rotations in which deep-rooting leguminous crops are frequently grown. Results obtained from the soil experiment fields of Illinois show that some soils respond highly to phosphate fertilization, while others give a very low response or none. Reports from county farm advisers and farmers in general are in agreement with these experimental results.

It should be noted that the total quantity of phosphorus in a soil is not a reliable indicator of the probable response to phosphate fertilization. Apparently it is a matter of solubility or the chemical form in which the phosphorus exists rather than total quantity.

A simple field test has recently been devised at the Illinois Experiment Station which will distinguish soils having a high amount of available phosphorus from those having a low amount. Information concerning this test is furnished in Bulletin 337, "A Field Test for Available Phosphorus in Soils."

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate and superphosphate. Other valuable carriers of phosphorus are bone meal and basic slag.

Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer. Considerable experimentation in the finer grinding is under way in the hope of increasing the plant-food value of the product and thus make possible a reduction in the amount that it is necessary to apply.

Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further processing, different concentrations are produced. The most common grades of superphosphate now on the market contain 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Likewise the 12 to 15 percent of phosphorus in rock phosphate corresponds to 29.5 to 34.3 percent of phosphoric acid. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food, altho this fact has little agricultural significance for Illinois, where the soils generally are sufficiently stocked with sulfur. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than is the phosphorus in raw rock phosphate, altho there is often good response in the crops immediately following the application of rock phosphate.

Obviously the carrier of phosphorus that will give the most profitable returns, considered from all standpoints, is the one to use. The question of which is the most profitable, however, remains unsettled, altho it has been the subject of much discussion and investigation. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

On several of the Illinois soil experiment fields rock phosphate and superphosphate are being compared in systems of management looking toward permanent soil improvement, and are applied in amounts corresponding approximately to equivalent money expenditures. So far as these comparisons show, there

appears to be little consistency in the results. In some years and on some crops superphosphate has furnished the greater profit; in other years and on other crops the reverse is true. In some cases neither material has paid for its cost, indicating that phosphorous is not a limiting factor in production on all soils. On the whole, therefore, if possible residual effects are disregarded, there appears to be no indisputable evidence for general discrimination between the two forms of phosphate.

Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium altho it exists mainly in a very slowly soluble form and probably only a very small percentage of the total potassium exists in a form available to plants at any one time.

Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils usually respond to potash fertilization. The Illinois Experiment Station has demonstrated in field experiments located on peat land that the difference between success and failure in raising crops on such land depends upon the application of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certain soil types that are rather high in organic matter, including peat and dark-colored sandy, silt, and clay loams. The unproductiveness of these soils is probably due largely to the unavailable condition of the soil potassium as well as to an unbalanced condition of the plant nutrients resulting from an excess of nitrate nitrogen. The addition of potash has a beneficial influence upon both of these unfavorable conditions.

Potash fertilizer may be procured in the form of one of the potassium salts, such as the chlorid, sulfate, or carbonate, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content.

Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned above, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

Use of Mixed Commercial Fertilizers

A mixed commercial fertilizer is a combination of substances containing either two or three of the plant-food elements nitrogen, phosphorus, and potassium. If the material contains all three of these elements, it is said to be a "complete" mixed fertilizer; if only two of the three are present, it is said to be an "incomplete" mixed fertilizer.

A complete mixed fertilizer has the general formula $N–P_2O_5–K_2O$ (nitrogen, phosphorus pentoxid, potassium oxid), the proportions of the elements varying according to the way in which the material is compounded. By substituting figures for the letters in this formula the percentage composition of the fertilizer is indicated. Thus a fertilizer of the formula 5-15-5 contains 5 percent nitrogen, 15 percent phosphorus pentoxid (usually designated as phosphoric acid), and 5 percent potassium oxid (usually called potash). Translated into pounds, this means that a ton of the fertilizer contains 100 pounds of nitrogen, 300 pounds of phosphoric acid, and 100 pounds of potash. For the benefit of those who are accustomed to think in terms of the simple plant-food elements rather than these combinations, it may be explained that the above amounts correspond to 100 pounds of the element nitrogen (N), 131 pounds of the element phosphorus (P), and 83 pounds of the element potassium (K). Changing the formula to read 0-15-5 indicates that no nitrogen is contained in it; 5-15-0 means that no potassium is present; and 5-0-5 indicates that phosphorus is absent.

In compounding these fertilizers, several ingredients carrying a single kind of plant-food element may be used. For example, a portion of the total nitrogen may be furnished by sodium nitrate, while another portion may be carried in dried blood or in ammonium sulfate. In addition to these plant-food materials, fillers and conditioners are often used in such amounts as to make the finished product contain the desired percentage of plant food.

A distinction between what are considered "high-grade" and "low-grade" fertilizers is now being made upon the arbitrary basis of a total of 16 so-called "units of plant food." Thus a 2-8-2 fertilizer carrying 12 units of plant-food would classify as a low-analysis grade. The advantage of using the higher grade products is becoming more and more generally recognized by both consumers and producers of fertilizers. In the latest developments still more concentrated forms of fertilizers are being produced containing as much as 60 units of plant food. If the economy of production and the agricultural value justify the general use of materials of such high concentration, there should be a great saving in the cost of transportation and handling thru the use of fertilizers of this type.

The question arises repeatedly regarding the employment of mixed commercial fertilizers, and particularly their employment in connection with a basic program of soil improvement built around the use of legumes and limestone where necessary. An important principle to be borne in mind in the use of any fertilizer is represented in the so-called "law of the minimum," that is, that no benefit can result from the application of a given plant-food element unless the need for that element is a limiting factor in plant growth. If, for example, there is already in the soil enough available phosphorus to produce a 40-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only 40 bushels or less, all the phosphorus one might apply would be absolutely ineffective in increasing the yield beyond this 40-bushel limit.

The most serious objection to the indiscriminate use of mixed commercial fertilizers lies in the fact that frequently only one, or perhaps two, of the plant-food elements carried by the fertilizer are actually needed, in which case a useless expense is incurred for the unnecessary element or elements.

This question of the use of commercial fertilizers is exceedingly complicated because so much depends upon numberless conditions of soil and season. We may be able to analyze in part the conditions of the soil, but we are powerless in predicting the conditions of the oncoming season. A given fertilizer may pay a handsome profit this season but on the same field next year may be absolutely without effect, or even detrimental to the crop. That is why it is impossible to make any general statement or to give a blanket recommendation concerning the use of such fertilizers.

The matter finally resolves itself into two questions: cost of material and benefit derived. Fortunately the cost of material can be definitely determined. In order to get an idea of the expense of applying mixed commercial fertilizers, perhaps we cannot do better than to figure the cost per acre based upon the published recommendations and price quotations of a fertilizer company. The following estimates are based upon the recommendations of such a company as given for the dark-colored silt or clay loam soils of Illinois on land having had manure and clover, and the prices are those quoted for the spring of 1929.

Thus, for the corn crop, 150 pounds per acre of a 5-15-5 fertilizer is recommended to be applied in drills or hill-dropped. The price of this fertilizer is quoted at $53.15 a ton, which would make the cost $3.99 per acre. According to an official report, the farm value of corn for December, 1928, in Illinois was 70 cents a bushel. At this rate an increase of 5.7 bushels of corn per acre would be required to cover the cost of the fertilizer, taking no account of the extra expense in applying it.

For spring grains the recommendation is to use a 0-21-9 fertilizer at the rate of 250 pounds an acre if drilled or 400 pounds if broadcast. The price is $45.10 a ton, thus making the cost per acre $5.64 drilled or $9.02 broadcast. If the spring grain were oats, valued at 38 cents a bushel, the increase in yield to cover the cost of fertilizer would have to be nearly 15 bushels an acre in the case the fertilizer were drilled; if it were broadcast nearly 24 bushels would be required to pay the cost before any profit would be realized. If instead of oats the spring grain were wheat valued at $1.02 a bushel, the increase in yield necessary to pay for the fertilizer would be 5½ bushels if the fertilizer were drilled and nearly 9 bushels if broadcast. In like manner the recommended application for potatoes is found to cost $13.13 an acre if the fertilizer is drilled and $26.25 if broadcast. The application recommended for pastures and meadows would cost $13.13 an acre.

The above examples afford some idea of the cost of using mixed commercial fertilizers for the production of our common field crops in so far as the prices quoted remain representative. Unfortunately it is impossible to furnish information with the same certainty concerning the profit that is likely to be derived from these fertilizers, for that will depend upon several varying factors, mainly the amount of increase in yield and the price received for it.

What kind of fertilizers will be profitable and under what particular conditions they will pay must be determined mainly on the basis of actual experience. In this connection it should be borne in mind that in all experimental trials great care must be exercised in drawing conclusions. The soil of a farm or even of a

field is seldom perfectly uniform thruout, and differences in yield really due to differences in soil may easily be mistaken for effects of the fertilizer treatment. Therefore small differences in yield should be critically considered before being accepted as significant. It is particularly risky to base conclusions upon the results of a single year, because of peculiar seasonal effects. Never are two seasons exactly alike, and the results of this year may not apply next year. If outstanding effects from fertilizers occur the first year they are tried, such results may be taken as indicative and accepted as a tentative guide for further work, but final conclusions should be withheld until these results are well confirmed in subsequent trials.

To what extent mixed commercial fertilizers can be profitably employed in connection with a basic program of soil improvement is a problem of great consequence. No doubt there are many instances in which such fertilizers may be used with profit, but it is just as certain that in many other instances their use would result in financial loss. Before investing in mixed fertilizers, farmers should carefully consider the cost, which, as explained above, is an item that can be definitely determined. With the investigations now under way, the Experiment Station hopes soon to be in possession of much more definite information than now exists regarding the use, under present-day conditions, of these mixed commercial fertilizers.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927
40 Whiteside, 1928
41 Henry, 1928
42 Morgan, 1928
43 Douglas, 1929
44 Coles, 1929
45 Macon, 1929
46 Edwards, 1930
47 Piatt, 1930
48 Effingham, 1931
49 Wayne, 1931

UNIVERSITY OF ILLINOIS-URBANA
Q.630.7IL6SR C005
ILLINOIS AGRICULTURAL EXPERIMENT STATION
49
3 0112 019543765